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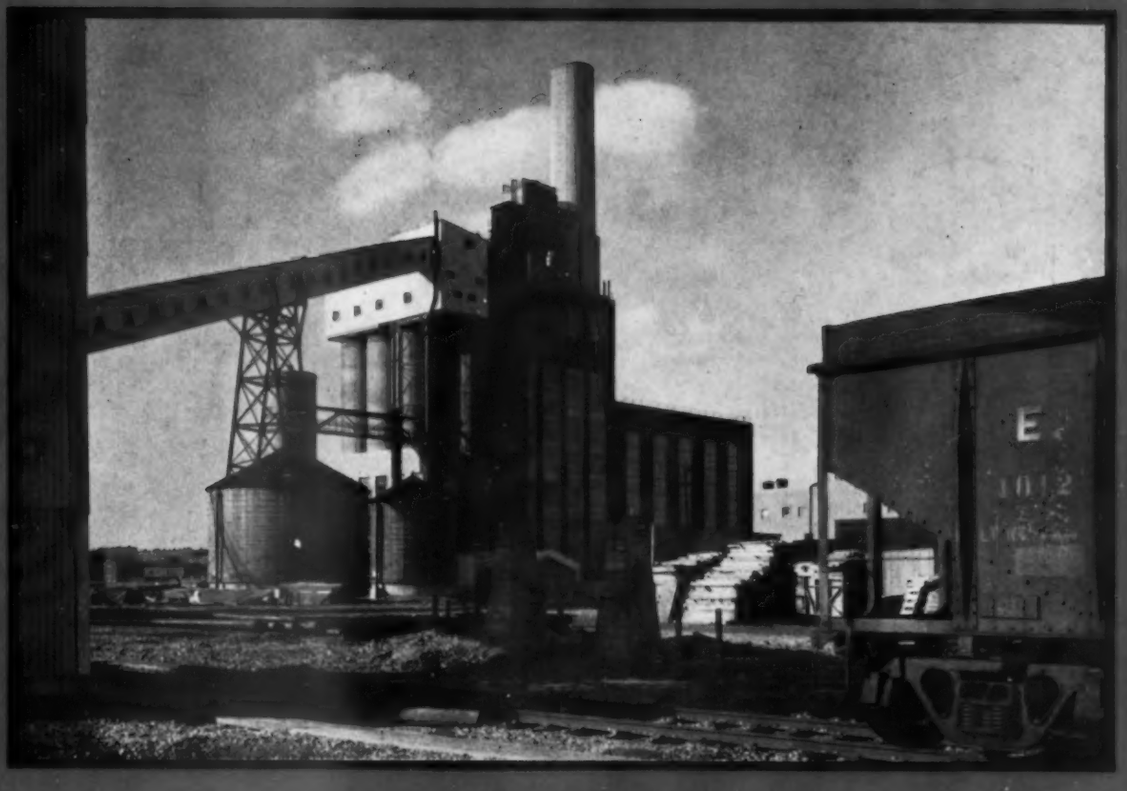

Coal handling at Mystic Station

New Power for Old Boston ▶

Operation of Steam Plants in Combined Steam and Hydro System ▶

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COMBUSTION ENGINEERING

200 MADISON AVENUE NEW YORK 16, N. Y.

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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CONTENTS

FOR APRIL 1944

FEATURE ARTICLES

New Power for Old Boston ..... *by G. A. Orrok, Jr., and W. P. Saunier* 32

N.A.P.A. Standardizes Statistical Forms for Coal Users 40

Operation of Steam Plants in Combined Steam and Hydro System ..... *by A. T. Hutchins and Howard Duryea* 42

A.S.M.E. Spring Meeting at Birmingham—Stoker Fuel-Bed Studies, Oblique Radiation on Boiler Tubes, Pulverizer Maintenance, Operation of Hydro and Steam Capacity, Adjustable-Blade Pumps 46

EDITORIALS

A Forecast of Power Demand 31

Watch the Smoke 31

George A. Orrok 31

DEPARTMENTS

Review of New Books 54

Advertisers in This Issue 56

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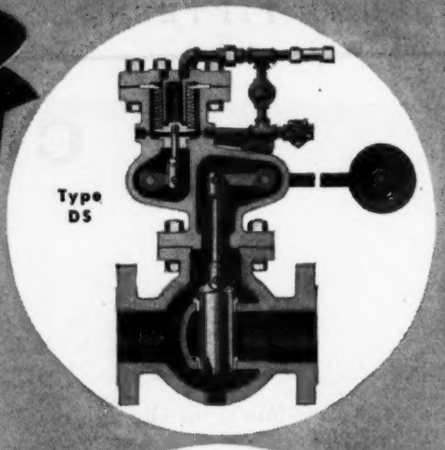

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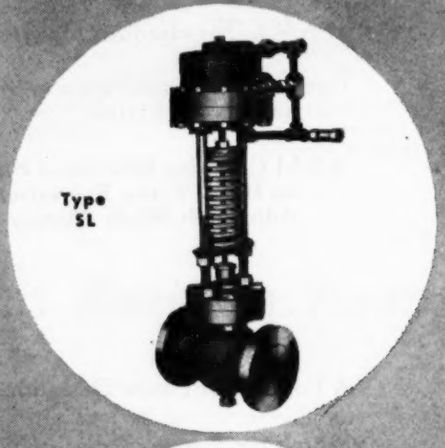

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EDITORIAL

A Forecast of Power Demand

In the current issue of the Edison Electric Institute *Bulletin*, W. M. Carpenter, economist for that organization, discusses the probable electrical utility situation during the transition period leading to the establishment of full peacetime economy, which he places in 1947. Assuming that the peak of power demand has already been reached and that a recession in demand is in sight during the remaining war period, his analysis points to a post-war relation between capacity and use comparable to the average for the pre-war years 1936–38. Moreover, indications are that the growth in capacity during the ten years from 1937 to 1947 will have averaged about $2^1/_4$ per cent per annum, which is somewhat less than that during the preceding decade, owing perhaps to the more highly integrated power supply brought about by war necessity. The anticipated use factor for 1947, while considerably below the present figure, is indicated as comparable to that of 1936–37.

Although the study envisions a substantial post-war growth in residential, rural, and small commercial load, it estimates a fifty per cent drop in industrial load from that attained in 1943, which would bring it down to about the 1937 or the 1939 level. However, inasmuch as the increase represents higher priced power, and the decrease, lower priced power, the assumption is made that gross revenue will be little affected.

The predictions take into account the fact that purchasing power for consumer goods will depend to a large extent on mass employment and that consumers will be carrying a heavy tax burden for a number of years to come. There are also other factors, on an unpredictable nature, such as possible competition from Government-owned plants, shifts in areas of power demand, and ability of the Government to hold down inflation. Still another factor, not mentioned specifically but scarcely overlooked, is the greatly increased capacity installed in private plants engaged in war production, which upon reconversion to peacetime manufacture will take the place of utility load.

It would appear then, from Mr. Carpenter's figures, that the utility industry in post-war days might be expected to take up where it left off at the time we entered the war and then proceed along normal lines of expansion.

While he has access to the most authentic sources of information within the utility field, there are doubtless many who will view his forecast as on the conservative side; that is, those representing the school of thought which sees, in depleted stocks, pent-up demand for goods and potential exports, a new high level of peacetime production. If subsequent events bear out this line of thinking, the utilities will benefit accordingly.

Watch the Smoke

Because of the fuel situation which prevailed during the past winter in certain localities in the East, some of the smaller power plants and numerous heating installations that had been accustomed to burning anthracite found it necessary to change over to bituminous coal. This change has been reflected in the atmospheres of some of our cities along the North Atlantic Seaboard. As might be expected, office and loft buildings, apartment houses and some residences are the chief offenders.

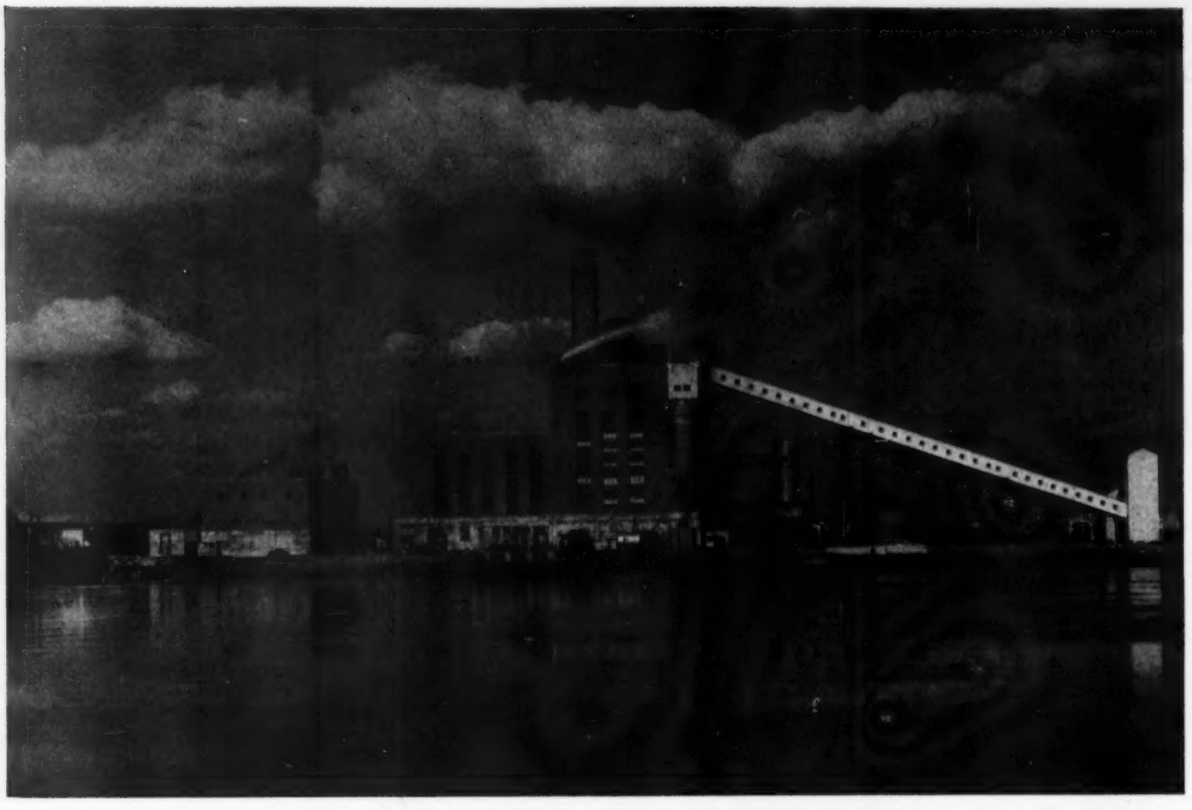
In some instances the firing equipment is not well suited to burning bituminous coal and it is also probable that inexperience and carelessness in firing are contributing factors. There may also be a tendency for some smoke enforcement bodies to show leniency in view of emergency conditions or due to lack of enforcement personnel; although there is little excuse for countenancing habitual offenders.

Since smoke is indicative of poor combustion, the aggregate fuel waste may be appreciable, and in this respect the National Fuel Efficiency Program, which is now being launched, should be of assistance, both in effecting fuel savings and in reducing smoke. Moreover, with the approach of warmer weather the situation should clear up to some extent.

Before the war, much progress had been made in achieving cleaner atmospheres in our cities to which improved firing equipment, means for detecting smoke, education and the machinery of enforcement all contributed. Despite emergency conditions it would be a grave mistake to permit retrogression, for it is anticipated that post-war days will see a renewed popular demand for clean atmospheres in our cities.

George A. Orrok

As we are about to go to press word comes of the passing of George A. Orrok—"Uncle George" as many of his friends were wont to call him. He was one of the rapidly diminishing circle of "elder statesmen" who led the thinking of twenty or twenty-five years ago; but unlike many of the others who retired at the usual age, he kept on and at seventy-seven was still actively engaged in consulting work. Mr. Orrok's long span of close association with the power field and his insatiable habit of collecting data and information, rendered him a veritable encyclopedia of development over the last half century. His was also an historical type of mind which led him to delve into much that had preceded and formed the basis of modern engineering practice, and his writings on such matters were most entertaining and instructive. A gentleman of the old school, with conservative New England background, he will long be remembered for his contribution to the engineering profession.



View of station looking north from across the Mystic River

New Power for Old Boston

By G. A. ORROK, JR.* and W. P. SAUNIER†

This station is designed on the unit system. The first unit, which recently went into service, consists of a 50,000-kw condensing turbine-generator supplied with steam at 1200 psi, 910 F by a 430,000-lb per hr steam generator equipped with both an economizer and air preheater. A fly-ash recovery system is installed.

THE Boston metropolitan area has been served by the L Street Station located east of the city, and by the Edgar Station which is to the south. Transmission and distribution to the northern part of the city and to the districts beyond have been progressively more difficult with the growth of the system load so that, when it became necessary to add to the system generating capacity, plans were made to provide a new generating station and new switching facilities north of the city.

On the north shore of the Mystic River within sight of Bunker Hill Monument stands a new steam electric generating plant, the Mystic Station, the latest addition to the Boston Edison Company system. The main building is built upon concrete-filled, steel-pipe piles which reach down through many strata of silt, clay, sand and gravel to the rock which lies from 110 to 150 ft below the ground floor level of the building. The switch house, screen-well house, coal-handling structures and sundry small buildings rest on the uppermost stratum of firm clay or upon piles of various kinds extending to it.

The main building is a concrete and brick structure with a continuous-frame steel skeleton and with generous areas of steel-sash windows. The design is marked by the absence of ornamentation within and without, a pleasing appearance being obtained by effective arrangement of mass and panels and by color contrast. The continuous-frame design of the support steel eliminates all cross-bracing, thereby enhancing the appearance of the interior of the building and avoiding the restrictions which bracing imposes. The turbine-room crane, spanning nearly a hundred feet, has a main hook for a lift of 125 tons and an auxiliary hook for a lift of 15 tons. In the boiler room operating aisle a 10-ton hand crane serves the boiler feed pumps. A passenger-freight elevator of 2500 pounds capacity operates between the ground floor level and the roof level nearly a hundred and twenty-five feet above.

* Boston Edison Company.
† Jackson & Moreland, Engineers.

The ventilation system adopted for the main generating building has several unusual features. The primary aim of minimizing the vertical movement of air has been effected by providing three concrete floors in the boiler house and using closure plates at equipment openings. With generous air inlets on the west wall of the turbine room and no dividing wall between the turbine and boiler sections, the propeller-type ventilating fans located in the east wall of the boiler room produce a horizontal flow of air across the boiler room between the several solid floors. At the top of the boiler, blowers are installed to furnish cooling air for men operating the furnace-roof soot blowers or lancing the superheater, if this should prove necessary. The forced-draft fan, located on the concrete fan floor above the boiler, provides all the ventilation needed at this floor, the air being drawn in through windows on the south and west walls and through the clearance spaces at openings in the roof.

Unit Design Adopted

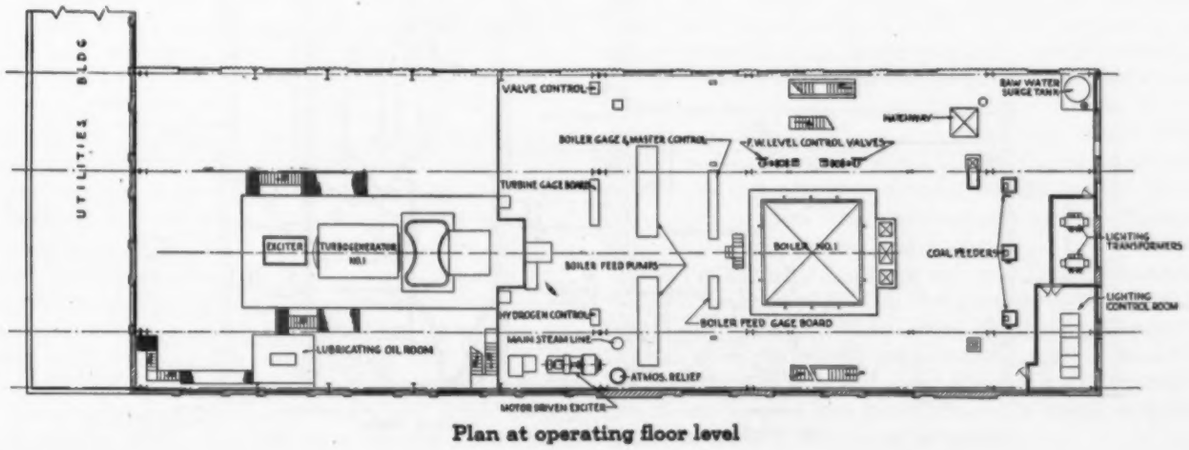
The station is designed on the unit system with one boiler and turbine, together with auxiliary equipment, operating as a unit. Provision has been made for some interconnection between units but, in general, these ties will serve under emergency conditions only. The coal-handling system will be common to all units. The condensate storage tank, the raw-water storage tank and the fuel oil supply system installed for Unit No. 1 will also serve Unit No. 2.

The turbine-generator has a rated capacity of 50,000 kw and operates with steam at 1200 psi gage and 910 F, turning 3600 rpm to generate 3-phase 60-cycle current at 14,400 volts. The generator is hydrogen cooled with a normal rating of 50,000 kva which can be increased to 57,500 kva by raising the hydrogen pressure to 15 psi gage. An exciter is mounted at the outboard end of the generator and is driven from the generator shaft through reduction gears. Steam passes through eighteen stages to a crossover connection supplying a double flow three-stage section through which it passes to the condenser. The unit is mounted crosswise of the turbine room on a massive, island-type pedestal of steel and concrete construction which rests on steel piles extending about 130 ft to rock.

The steam condenser, mounted horizontally beneath the turbine, is of the single-pass, surface type with vertically divided water boxes and has 6216 tubes $^{7}/_{8}$ in. O.D. by 24 ft long with a total outside surface of 33,800 sq ft. The condenser is served by duplicate sets of two-stage steam-jet air ejectors with inter- and after-condensers. Duplicate three-stage condensate pumps remove the condensate from the hotwell and discharge it to an outdoor wooden storage tank of 250,000 gal capacity. Two vertical-shaft, motor-driven circulating water pumps are located in an intake house at the river edge. The inlet for each pump is equipped with a rack of creosoted wood, a timber shutoff gate and a revolving screen. The pumps discharge through a high level 60-in. pipe to the condenser. Because of the expected differential settlement between the main station building and the screen house, special flexible bell-and-spigot connections are provided at each building. The line is valved so that either half of the condenser can be run independently and so that the second pump can serve as a spare for the second unit when that is installed in the future. Normally one pump will serve the condenser, delivering 41,000 gpm to condense a maximum of 310,000 lb of steam per hr at 50,000 kw output. Two pumps can be operated in parallel to deliver 62,000 gpm to maintain a high vacuum during summer.

Steam-Generating Unit

The steam generator is a three-drum bent-tube boiler with a water-cooled furnace, superheater, economizer and air preheater, designed to deliver continuously 430,000 lb of steam per hour at 1250 psi gage and 910 F total temperature, but all pressure elements are designed for a pressure of 1400 psi gage. The entire unit, save only the air preheater, is suspended from girders above the boiler so that the expansion is downward to a flexible connection between the furnace bottom and the ash hopper. The superheater of the pendent, convection type is in two sections with three headers and is sized to give design steam temperature at a load of 350,000 lb per hr. An automatically operated damper permits part of the gas to bypass the second section of the superheater to maintain a constant outlet steam temperature when the unit is operating at loads in excess of 350,000 lb per hr. The economizer is of the continuous-loop, horizontal, fin-tube type arranged for parallel flow of gas and water. It is suspended beneath the boiler steam drum between two walls of boiler tubes which connect the steam drum and the bottom drum.



Plan at operating floor level

The vertical-shaft regenerative air preheater is mounted separately from the boiler on the fan deck.

The furnace walls, roof and hopper bottom are completely lined with close-spaced bifurcated water tubes which are backed up with insulating brick, rock wool insulating blanket and a steel casing. Burners are mounted at the four corners of the furnace to fire tangentially. Each of the four burner boxes provides openings for the admission of secondary air and houses three riffle-type coal burner tips which may be moved in unison by remote control through a vertical angle of 45 deg, half of this above and half below the horizontal. This adjustment provides a supplementary superheat temperature control. In addition to the coal burners each burner box has two non-adjustable oil burner tubes into which oil torches may be inserted. The eight tubes will accommodate torches of sufficient capacity to operate the steam generator at full rating but they are normally used to support the lighting-off torches.

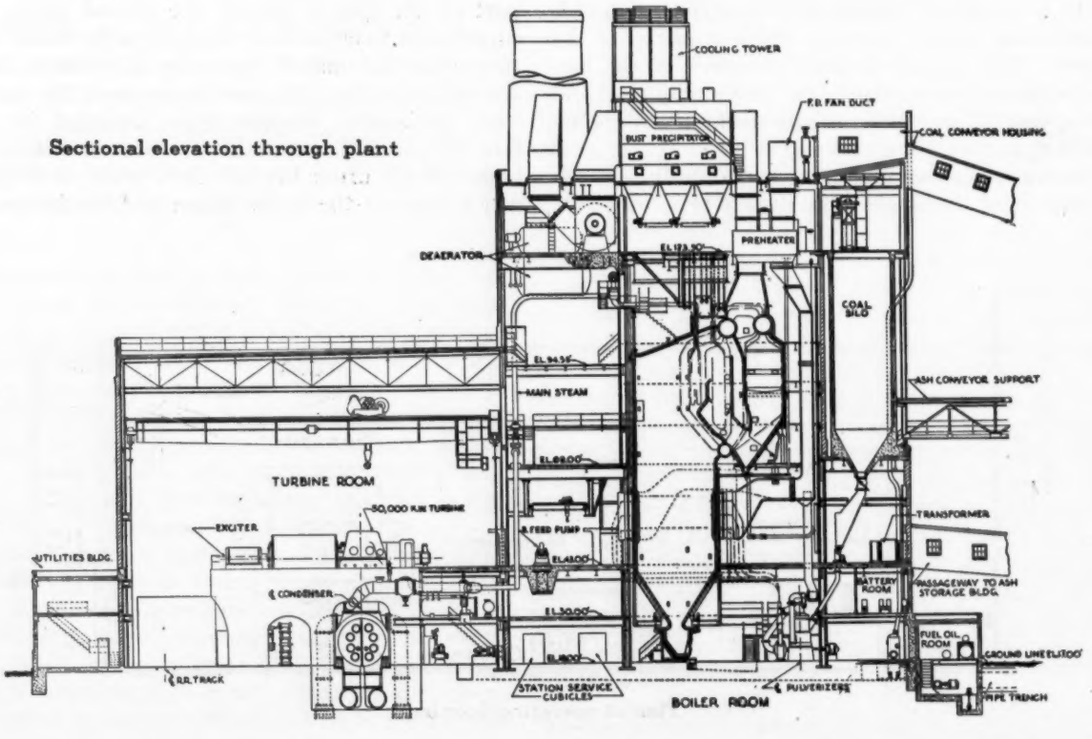
An extensive arrangement of soot blowers is employed for cleaning the heat-absorbing surfaces throughout the steam generator. Forty elements are installed, twenty on the furnace walls and roof to operate with a steam pressure over 600 psi and twenty in the boiler and economizer to operate with a steam pressure of 300 psi. In addition to the elements initially installed provision has been made for the future installation of twenty elements in the furnace and six in the boiler section should they be needed. Experience has indicated the necessity of cooling the retractable elements installed in the walls and roof of the furnace and, to this end, air from the forced-draft fan is piped to each of the twenty furnace elements.

Coal-Handling System

The primary fuel for the station will be coal delivered in railroad cars from an independent adjacent coal yard. Coal comes to the supplier both by rail and by ship and a contract requires the yard to hold available an adequate reserve of fuel for the station so that, for the present, no large storage is required at the site. Cars are unloaded into a track hopper which is long enough to take care of all the discharge spouts of a car at the same time. A reciprocating feeder regulates the flow of coal to the cross conveyor which discharges to the first main belt conveyor. This conveyor carries the coal over a continuous weigh scale and over a magnetic head pulley at the top of the transfer house and discharges to the second main conveyor or to the stocking-out conveyor for delivery to the storage pile. The second main conveyor, with a slope of 11 deg, carries the coal to the breaker house and discharges into the 10-ft 6-in. by 17-ft rotary coal breaker which is equipped with a hammermill rotor. In the breaker the coal is reduced in size so that it will all pass through a $1^1/_4$-in. diameter opening and 75 per cent will pass through a $^3/_4$-in. diameter opening. The breaker serves to eliminate stones, bony and non-magnetic materials such as wood, straw, rags and copper wire. A belt-feeder conveyor at the bottom of the breaker delivers the cleaned and sized coal to the third main-belt conveyor which carries it to the top of the station building whence it passes by gravity and by a feeder belt to three 16-ft 6-in. diameter concrete silos, each of which holds 250 tons. Each silo discharges to an automatic coal feeder supplying a bowl-type pulverizer from which an exhauster removes the coal and delivers it in equal amounts to each of four burner nozzles located at the corners of the furnace.

The coal-handling system as installed has a capacity of 350 tons per hour which is adequate, when operated on a one-shift basis, for a two-unit station consuming 38 tons per hour at the maximum rating of 50,000 kw per unit. The main belt conveyors which are 36 in. wide operate at 300 fpm but can be arranged to run at 600 fpm to handle coal at the rate of 700 tons per hour.

Sectional elevation through plant



When the belt speed is changed, a second coal track and hopper will be provided and a duplicate coal breaker will be installed. The arrangement for feeding the various silos of the additional units has not been determined but ample space is available for two conveyors which may be fixed conveyors with belt trippers or a combination of fixed and shuttle conveyors.

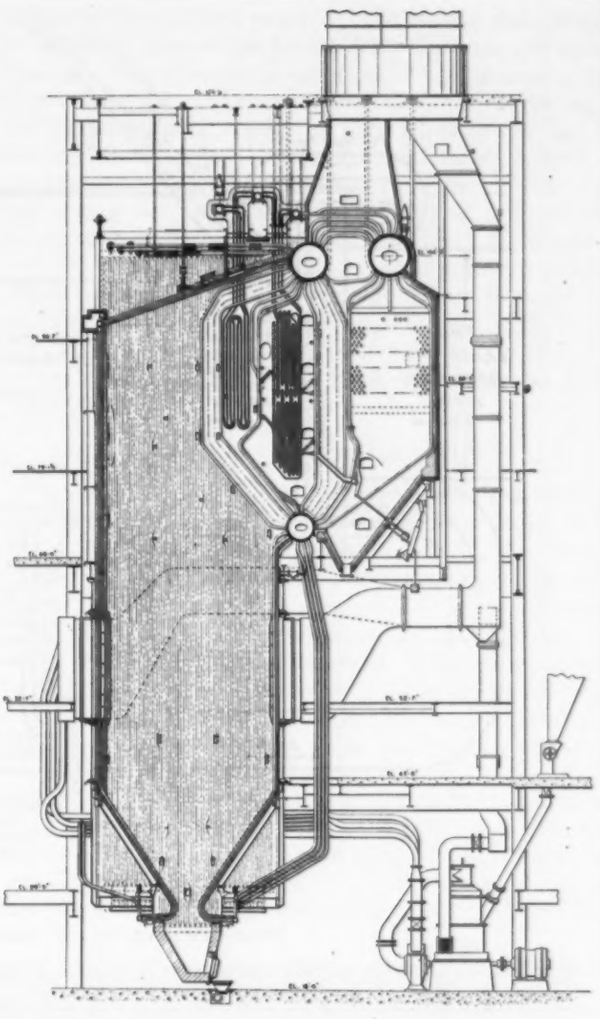
The design incorporates provision for duplication of the main conveyor from the breaker house to the silos and for the installation of a coal dock at the river with an inclined belt conveyor to the top of the breaker house. In order to provide for stocking-out coal which may in the future be received at a dock, the main conveyor between the transfer house and the breaker house is so laid out that it can be made reversible to feed onto the stocking-out conveyor. Consideration was given, also, to a car unloader of the tilting type and to a boom conveyor for feeding to a storage pile of 15,000 tons or more so that both of these devices could be installed when required.

Handling Condensate

Suction connections to two deaerator pumps are provided in the discharge line of the condensate pumps to the main condensate storage tank. The deaerator pumps deliver condensate through the 19th-stage turbine-extraction heater to the tray-type deaerating heater which operates under the variable pressure of the 14th-stage extraction point of the main turbine and the flow is automatically controlled to maintain as nearly as may be a constant level in the heater storage tank. The two 1500-hp boiler feed pumps are mounted on the main operating floor in front of the boilers and adjacent to the boiler operating boards. The center line of the pumps is 71 ft below the water surface in the deaerator storage tank and the design pressure at the pump inlets is 18 psi. The pumps are seven-stage double-suction, 3600-rpm, constant-speed, motor-driven units, each designed to deliver 500,000 lb per hr against a pressure of 1680 psi.

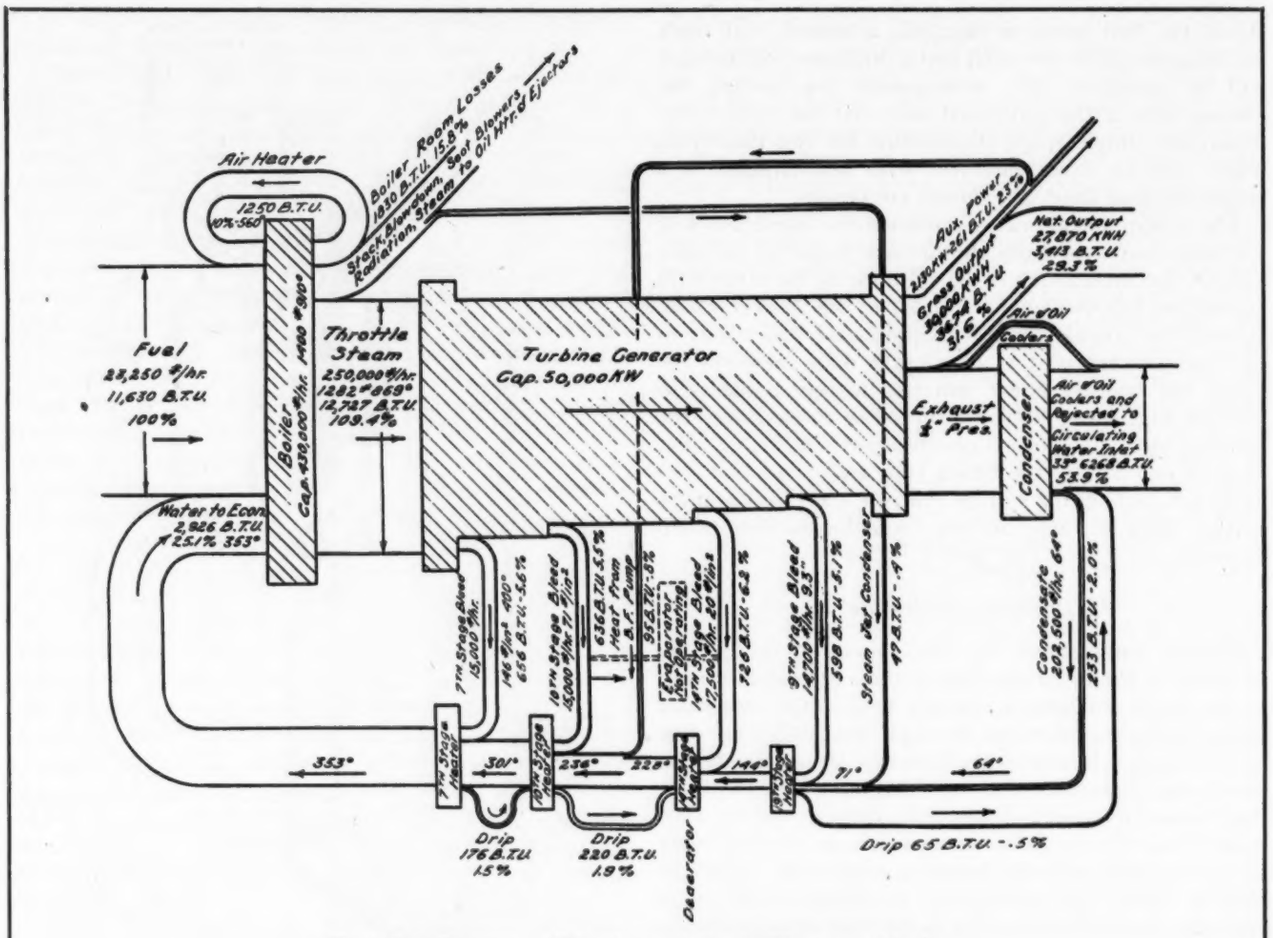
Since each pump is able to take care of the full requirements of the steam generator, only one pump is normally in operation and the second pump acts as a standby to come into service automatically if the boiler feed discharge pressure drops below a predetermined point. Each pump is equipped with an automatic bypass, actuated from a flow orifice in the suction line to the pump. When the flow to a pump drops to 50,000 lb per hr, the bypass control valve opens permitting water to discharge from the pump through a throttling orifice to the deaerating heater at a rate of 50,000 lb per hr. The bypass remains open until the total flow to the pump reaches 150,000 lb per hr when the valve closes.

Two feedwater lines run from the boiler feed pumps to the economizer inlet header. The line normally used delivers the feedwater from the pumps to the 10th- and then to the 7th-stage extraction heaters ahead of the regulating valve which is of the three-element control design and is responsive to the steam flow, the feedwater flow and the water level in the boiler drum. No excess-pressure regulators are used, the three-element control working with the full variable excess pressure provided by the pump characteristic. From the regulating valve, which is located at a convenient height above the operating floor, the line runs to the economizer header. The secondary feed line bypasses both high-pressure heaters and runs to a regulating valve adjacent to and of the same design as that on the normal feed line. From this point the secondary feed line runs to a separate connection in the economizer inlet header.



Cross-section through steam generating unit

The high-pressure feedwater heaters are of the U-tube, horizontal type designed for the shutoff pressure of the boiler feed pumps, 2100 psi. The forged-steel water boxes have locked-in head plates and for inspection and tube replacement the water-box tube bundle assemblies can be unbolted from the heater shells and withdrawn. The condensate from the 7th-stage heater flows through a float-operated valve to the 10th-stage heater which is of the drain-cooling type wherein the drain water is maintained at a level to flood a baffled section of first pass tubes around which the condensate is obliged to flow on its way to the heater outlet. The condensate discharges into a pump by which it is delivered through the heater-condensate level-regulating valve to the deaerating heater. At full load the two high-pressure heaters raise the water temperature from 275 to 390 F, but at lower ratings the inlet and outlet temperatures are lower because the pressure of the steam extracted from the turbine is lower at all stages.



Heat-flow diagram; all heat quantities in Btu per net kwhr

Heat quantities shown above ambient of 32 F. Data from Daily Records when at 30,000 kw somewhat below the most efficient load

Treatment of Makeup Water and Boiler Water

Makeup water to compensate for the losses from the boiler-water system is supplied from the plant water supply lines which connect with the Metropolitan District Water System. The raw water is first treated in a carbonaceous zeolite softener operating on the sodium cycle and having a capacity of 15,000 lb per hr. The makeup water passes to a single-effect evaporator of the same capacity supplied with steam from the 10th-stage extraction point of the turbine, the steam being at 86 psi gage and 410 F at a load of 40,000 kw. Steam from the evaporator passes into the 14th-stage extraction line to the deaerating heater at a pressure of 20 psi gage at rated load. The evaporator is designed for water of a total hardness of 34 ppm and total dissolved solids in excess of 70 ppm under which conditions the vapor from the unit is to contain less than 5 ppm total solids. As with the high-pressure feedwater heaters, the evaporator head and tube bundle can be unbolted from the shell and withdrawn horizontally for access to the tubes for cleaning or replacement.

The water in the boiler-water system is chemically treated by the addition of sodium sulphite and sodium hydroxide solutions at the deaerating heater and by the injection of sodium phosphate solution in one of the boiler drums. Provision has been made for the injection of sodium sulphate solution at the boiler drum if this treatment is deemed necessary. The high-pressure injection pumps are operated on a timed cycle with an adjustable automatic control device governing the sequential flow of phosphate solution and condensate for washing out the lines. The control can be arranged to control the flow of sulphate solution if its use becomes desirable.

Ash and Fly-Ash Handling

Provision is made at three points in the gas circuit for the deposit of ash and dust and for its removal by means of a vacuum ash system. The first point is at the bottom of the furnace where the steeply sloped hopper bottom directs the falling ash to a firebrick lined hopper extending the full width of the setting. From the hopper the ash is hoed through five water-cooled, counterweighted doors to grid-covered feed spouts discharging to the ash-conveyor pipe. The second deposit point is beneath the economizer back of the mud drum where four hoppers guide the fly ash to four solidly attached, valved discharge pipes connected to ash feeders in the ash-conveyor pipe. The third deposit point is at the electrostatic, steel-plate type dust precipitator beneath which are six hoppers discharging to motor-operated feeders in the ash-conveyor pipe. The highly efficient dust precipitator is located ahead of the induced-draft fan so that the life of the fan blades is increased by the removal of the dust from the flue gases.

The ash is carried in the conveyor pipes on a stream of air induced through openings at the ends of the branches by the vacuum produced in the conveyor system by a displacement-type blower. Only one branch of the conveyor piping is in service at any time and the air and dust from this branch travel through the conveyor main to a separator mounted above a tile dust-storage bin outside the main building. From the separator the air returns to the rotary blower, located on the fan floor in the main building, by which it is vented to the atmosphere through a discharge head above the roof. A steam-jet vacuum pump operated by steam at 250 psi is provided as a spare to the rotary blower.

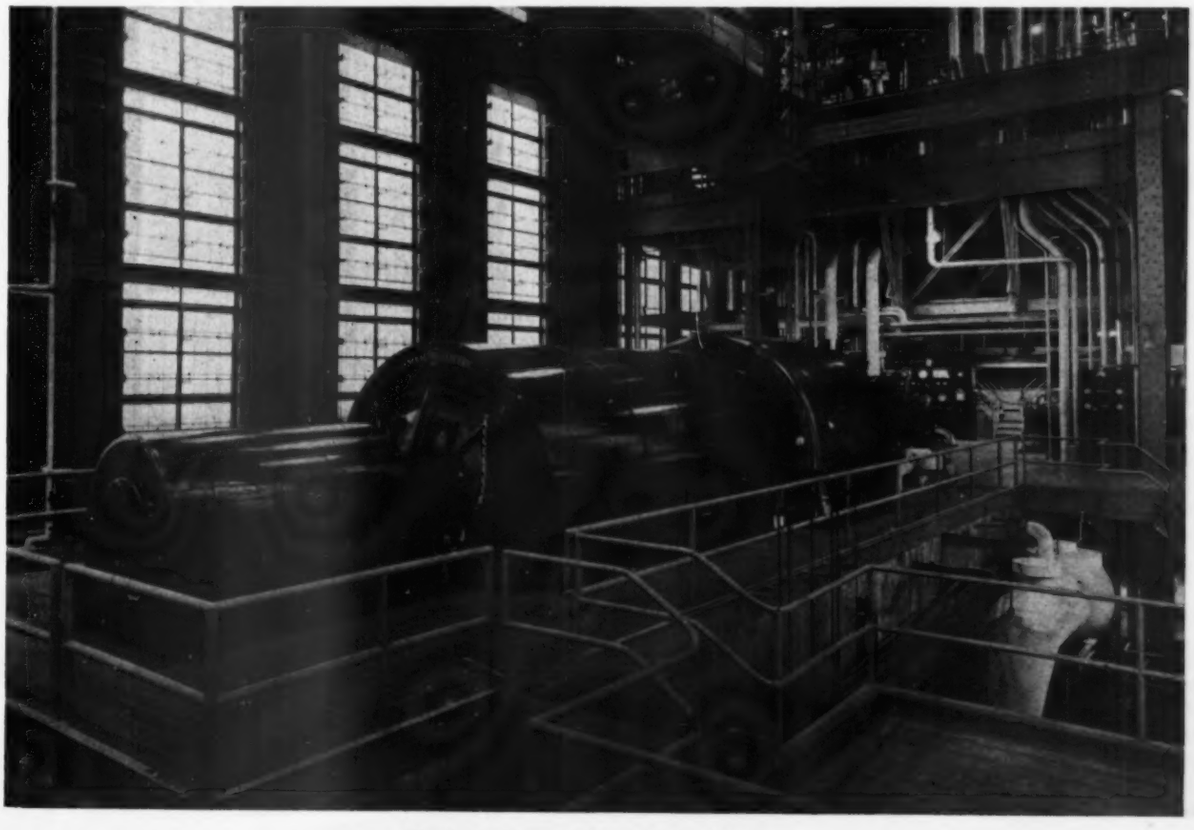
The ash-storage silo is mounted on a steel frame structure at a height sufficient to permit the passage of trucks beneath. When ash is removed from the storage silo, it is fed into a dustless unloader wherein the ash is moistened with water before it is discharged through a chute into a truck. For some time to come the ash will be used to fill in at the river edge behind a pile retaining wall.

Combustion-Control System

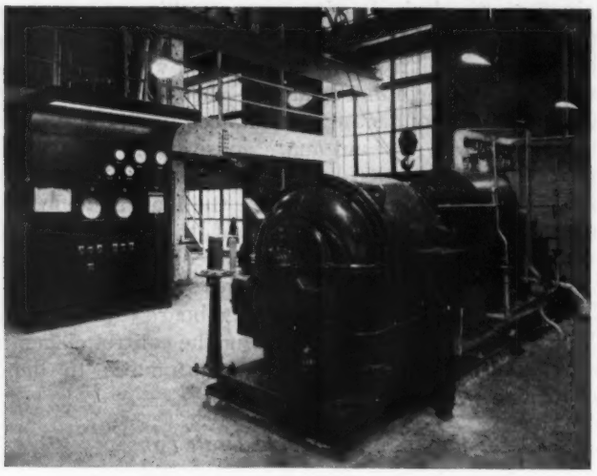
The combustion-control system is actuated by compressed air and is designed to maintain a predetermined steam pressure, steam flow-air flow relation and furnace draft. Loading pressure from the control elements at the gage board positions the pilot valves on the power cylinders operating the various pieces of apparatus. The coal feed is regulated by positioning the levers of the coal feeders supplying the pulverizer mills and the primary air supply is governed by positioning the inlet dampers to the mill exhausters. Furnace draft is maintained at the desired point by controlling the position of the inlet vanes of the forced-draft fan while the steam flow-air flow relation is maintained by adjusting the position of the contactor on the rheostat of the magnetic coupling connecting the induced-draft fan and its driving motor. An automatic positioning element is provided for the outlet damper of the induced-draft fan, but this device serves only when the load is below the minimum stable control point of the variable-speed coupling. The control elements, incorporating mechanisms for recording steam pressure, steam flow and air flow, are mounted on the boiler gage board together with the necessary devices for switching the control elements individually or collectively from automatic to hand operation.

Forced- and Induced-Draft Fans

The forced- and induced-draft fans, both driven by constant-speed motors, are installed on the fan floor above the boiler and just below the roof. The forced-draft fan is a double-inlet, vane-controlled, turbo-vane type centrifugal fan direct-connected to a 450-hp, 1200-rpm, 550-v motor. The fan draws air from the room in which it is located and discharges at the required pressure up to a maximum of 13 in. of water into the forced-draft ducts, through the air preheater and to the burners at the corners of the furnace. The induced-draft fan is a double-inlet, turbo-vane type, centrifugal fan with inlet boxes and with a louver-type outlet damper. The fan blades are forwardly curved at the inlets and radial at the outer edges and the center plate of the rotor is cut away to reduce erosion. Liner plates are provided on the fan blades and on the inner face and sides of the scroll



Turbine room looking toward boilers



Boiler feed pump and feedwater gage board

case. The fan is driven at variable speed by a 1250-hp, 900-rpm, 2300-v motor through a magnetic coupling. The magnetic coupling is a double-rotor device in which the rotors operate in a magnetic field controlled by a rheostat through which an excitation current is supplied to the winding of the lower speed rotor. The outer rotor, connected to the driving motor, has a squirrel-cage winding while the inner rotor, which is connected to the fan shaft, has the field winding. Each rheostat position provides a different speed-torque characteristic for the coupling, and control is effected by changing the rheostat position to the one which provides the speed and torque required by the fan at the moment.

The station piping conforms to accepted practice as to materials and thickness for plants in the same pressure-temperature class. Most lines are electric welded, with the valves generally welded into the lines. Carbon molybdenum steel pipe was employed for all lines carrying steam at 910 F. All small forged-steel valves are of the bolted-bonnet type. The pipe lines are grouped in parallel runs wherever possible and operating valves have been placed in accessible positions or provided with chain wheels. The pressure-reducing and desuperheating stations are conveniently located and adequate platforms are installed for enabling the operators to repair safety valves. All piping subject to wide variations in temperature is spring supported.

A radial-brick chimney of 16 ft 0 in. internal diameter at the top is built on a concrete base at roof level and is designed to serve two units. The design calls for a height of 136 ft 6 in. above the mat with a lining shell 50 ft high, but for structural reasons the top 40-ft section of the chimney was omitted and a temporary top ring was provided in the initial installation. When the second unit is installed the stack will be completed to the full height called for in the design.

Auxiliary Drives

All of the station auxiliaries are driven by motors provided with current at 2300 v or at 550 v from the station service system. A 6000-kva, 14,400/2300/575-v transformer, supplied from the generator bus, is provided as the normal supply service for the Unit No. 1 station service system. A 7000-kva, 25,000/2300/575-v transformer supplied from the 25,000-v switch house, which is tied in with outside sources of power, takes care of motors that are common to the first two units and serves as a spare. Motor-driven fans are provided on the transformers and with these in operation the capacity is increased by one-third. The transformer switches are so interconnected that the common bus transformer will take over the auxiliary load automatically in the event of a fault. The 1250-hp induced-draft fan motor and the 1500-hp boiler feed-pump motors are supplied at 2300 v through cables running in conduit from the switches to the motors. All other auxiliary motors are supplied at 550 v through individual cable connections in conduit.

LIST OF PRINCIPAL EQUIPMENT

Turbine-generator Rating—40,000 kw nominal, 50,000 kw maximum Steam conditions—1200 psi, 910 F to vacuum	General Electric Company
Steam condenser Surface, 33,800 sq ft	Worthington Pump & Machinery Corp.
Circulating water pumps Two 250-hp vertical, 41,000 gpm each at 14.5-ft head	Worthington Pump & Machinery Corp.
Steam-generator One 430,000-lb steam per hr at 1400 psi, 910 F, equipped with Elesco superheater and economizer and Ljungstrom air preheater	Combustion Engineering Company, Inc.
Induced-draft fan One 1250-hp variable-speed drive	B. F. Sturtevant Company
Variable-speed magnetic coupling	Electric Machinery Mfg. Corporation
Forced-draft fan One 450-hp with inlet vane control	B. F. Sturtevant Company
Coal pulverizers Three Raymond bowl type, 200 hp drive	Combustion Engineering Company, Inc.
Boiler feed pumps and motors Two 1500-hp, 3600 rpm, 500,000 lb per hr each	Allis-Chalmers Manufacturing Company
Flue-dust precipitator	Research Corporation
Feedwater heaters Three turbine-extraction, closed units	Foster Wheeler Corporation
Deaerating heater One 430,000 lb per hr with steam extracted from turbine	Worthington Pump & Machinery Corp.
Ash-handling system, completely pneumatic	United Conveyor Corporation
Combustion and feedwater control	Bailey Meter Company
Superheat control (electric)	Leeds & Northrup Company
Large auxiliary motors 2300-v and 550-v For draft fans, mills and circulating water pumps	Westinghouse Electric & Mfg. Company
Coal-handling system, initial capacity 350 tons per hr	Link-Belt Company
Cooling tower, 1250 gpm, 7 F diff. For generator, turbine oil and bearing cooling water	The Marley Company
High-pressure and circulating water valves	Chapman Valve Mfg. Company
Turbine-room crane 125-ton main hook and 15-ton auxiliary hook	Shepard Niles Crane & Hoist Corp.
High-pressure piping	M. W. Kellogg Company
Low-pressure piping	Lumsden & Van Stone Company
Cast-iron circulating water piping	Warren Foundry & Pipe Corp.
House-service transformers One 6000 kva One 7000 kva	General Electric Company Westinghouse Electric & Mfg. Company
Switchboards, 550-v and 2300-v	Westinghouse Electric & Mfg Company

More Air to make More Iron to make More Arms

Turbine Driven Blast Furnace Blower on test in De Laval Shops

Three De Laval BLAST FURNACE BLOWERS of the latest design are being built at the De Laval Works; two of which are for a steel company already operating four De Laval blowers having an aggregate inlet capacity of 262,000 cu. ft. per minute against 30 lb. gage maximum pressure.

Each of the new machines is rated at 90,000 cfm. of air, as measured at standard conditions of 60° F. and 30 in. barometer, and to deliver against 30 lb. per sq. in. maximum pressure, with an actual capacity of 97,800 cfm. at normal operating inlet pressure and temperature conditions.

The units are controlled automatically to deliver a constant weight of air.

The design and materials for the driving turbines are suitable for operation with a maximum steam pressure of 700 psig and maximum temperature of 775° F.

3825

De Laval STEAM TURBINE CO.
TRENTON 2, N.J.

MANUFACTURERS OF TURBINES . . . STEAM, HYDRAULIC; PUMPS . . . CENTRIFUGAL, CLOGLESS, ROTARY DISPLACEMENT, MOTOR-MOUNTED, MIXED-FLOW, PROPELLER; PRIMING SYSTEMS; CENTRIFUGAL BLOWERS and COMPRESSORS; GEARS . . . WORM, HELICAL, and FLEXIBLE COUPLINGS

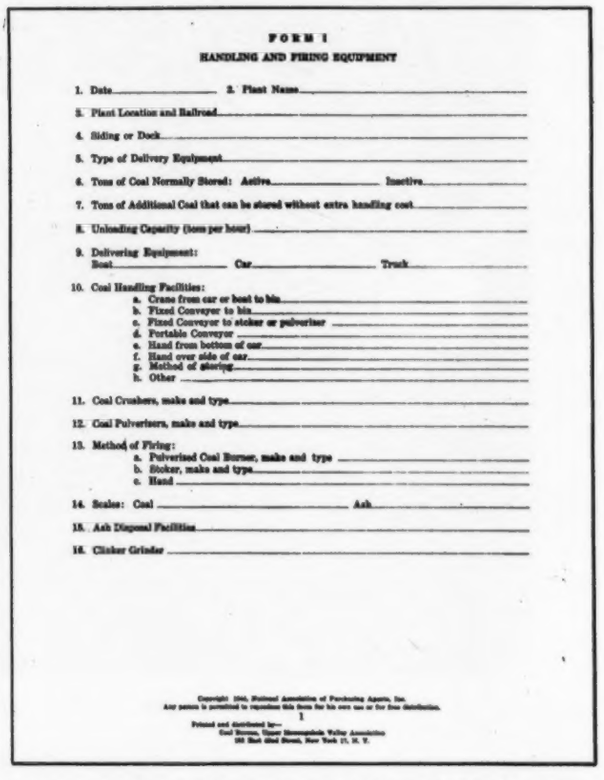
N.A.P.A. Standardizes Statistical Forms for Coal Buyers

This set of five forms, which were compiled with the aid of both producers and users of coal, is being made available to assist in securing the kind of coal best adapted to the requirements of the individual plant equipment and operating conditions. It is believed the field of coal selection can thereby be enlarged.

BECAUSE of the great variety in the design of steam-generating units and in their fuel-burning equipment, as well as the conditions surrounding their operation, it is important that both the purchasers and the sellers of coal have complete information available concerning each individual installation. To this end, the National Association of Purchasing Agents, through its Coal Committee and a Subcommittee on Boiler-Room Information, has compiled a set of forms for collecting such data. In doing so, the subcommittee was assisted by approximately fifty prominent combustion engineers, coal operators, government technicians, engineering professors, representatives of equipment manufacturers and coal users. The forms are being distributed by the Association from its offices at 11 Park Place, New York, and also from the office of J. E. Tobey, Director of the Coal Bureau of the Upper Monongahela Valley Association, Chanin Bldg., New York. The five forms are here reproduced with the idea that many COMBUSTION readers will find them of sufficient interest to warrant their use. They should be especially helpful at the present time.

The information called for in Form 1 will have to be collected only once and revised only at such time as the boiler plant equipment or the layout may be changed. It covers the equipment used in unloading the coal from the boat, railroad car or truck to the furnace, and also the disposal of the ash. It will be apparent that this information may be an important factor in the choice of fuel. The form covers much that will not apply to every plant, but operators of the individual plants will know best just what items to fill out in order to cover their own conditions.

Form 2, covering boiler dimensions and equipment, will likewise need be filled out only once unless the equipment or layout be changed. Most of these items will apply to all boiler installations. Although many coal buyers and engineers will not find it necessary to use all of this information regularly, they will find it convenient if trouble subsequently develops, and also if it becomes necessary to revise their buying and operating practices.



FORM 1

HANDLING AND FIRING EQUIPMENT

1. Date _____ 2. Plant Name _____
3. Plant Location and Railroad _____
4. Siding or Dock _____
5. Type of Delivery Equipment _____
6. Tons of Coal Normally Stored: Active _____ Inactive _____
7. Tons of Additional Coal that can be stored without extra handling cost _____
8. Unloading Capacity (tons per hour) _____
9. Delivering Equipment:
Boat _____ Car _____ Truck _____
10. Coal Handling Facilities:
a. Crane from car or boat to bin _____
b. Fixed Conveyor to bin _____
c. Fixed Conveyor to stoker or pulverizer _____
d. Portable Conveyor _____
e. Hand from bottom of car _____
f. Hand over side of car _____
g. Method of storing _____
h. Other _____
11. Coal Crushers, make and type _____
12. Coal Pulverizers, make and type _____
13. Method of Firing:
a. Pulverized Coal Burner, make and type _____
b. Stoker, make and type _____
c. Hand _____
14. Scales: Coal _____ Ash _____
15. Ash Disposal Facilities _____
16. Clinker Grinder _____

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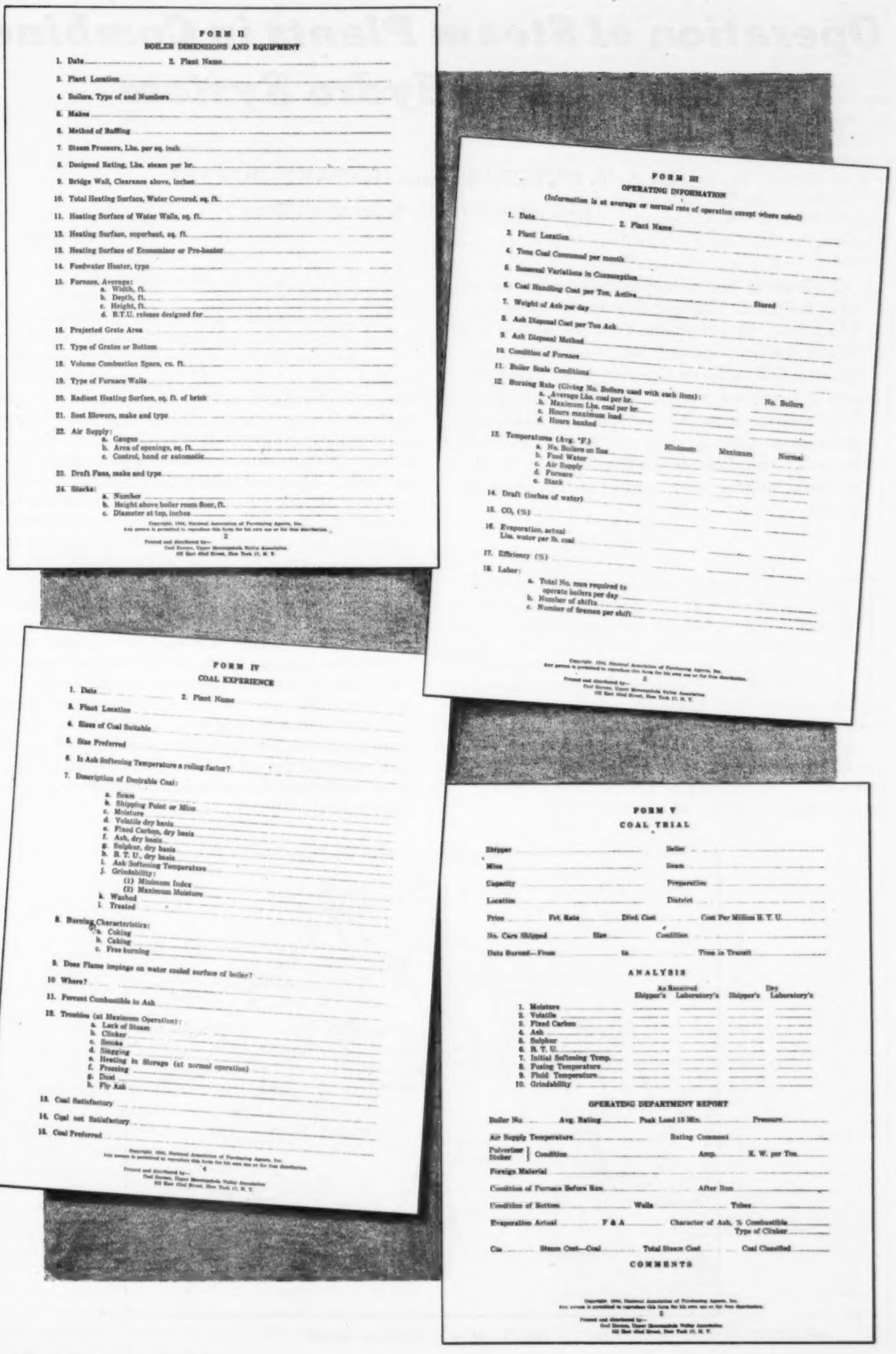
The operating information which is called for in Form 3 should be collected from time to time, at least annually, and for most plants monthly. It covers the day-to-day operation of the plant and shows the coal purchaser what to expect normally. Also, it should assist in enlarging the field of coal selection and show how well the coal that has been selected is performing.

Form 4, which deals with coal experience, ties together the information of the first three forms, and should be consulted frequently, especially when changing coals. Moreover, it will serve as a convenient checkup on what has been found by experience and gives the operator an opportunity to express his opinion based on this experience.

Finally, Form 5 should be used whenever making a coal trial. It is drawn up in a simplified form, covering only those essentials that will provide a comparison between the coals involved; but it is not intended that it should take the place of a report of a scientific boiler test where one is called for.

It is believed that use of these forms will facilitate the work of both the purchaser and seller and will tend to eliminate costly errors in coal selection which often result in increased maintenance, difficulty in carrying load or unscheduled outage.



FORM II

BOILER DIMENSIONS AND EQUIPMENT

1. Date ..... 2. Plant Name .....
3. Plant Location .....
4. Boilers, Type of and Numbers .....
5. Makes .....
6. Method of Baffling .....
7. Steam Pressure, Lbs. per sq. inch .....
8. Designed Rating, Lbs. steam per hr. .....
9. Bridge Wall, Clearance above, inches .....
10. Total Heating Surface, Water Covered, sq. ft. .....
11. Heating Surface of Water Walls, sq. ft. .....
12. Heating Surface, superheat, sq. ft. .....
13. Heating Surface of Economizer or Pre-heater .....
14. Feedwater Heater, type .....
15. Furnace, Average:
    a. Width, ft. .....
    b. Depth, ft. .....
    c. Height, ft. .....
    d. B.T.U. release designed for .....
16. Projected Grate Area .....
17. Type of Grates or Bottom .....
18. Volume Combustion Space, cu. ft. .....
19. Type of Furnace Walls .....
20. Radiant Heating Surface, sq. ft. of brick .....
21. Soot Blowers, make and type .....
22. Air Supply:
    a. Gauges .....
    b. Area of openings, sq. ft. .....
    c. Control, hand or automatic .....
23. Draft Fans, make and type .....
24. Stacks:
    a. Number .....
    b. Height above boiler room floor, ft. .....
    c. Diameter at top, inches .....

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FORM III

OPERATING INFORMATION

(Information is at average or normal rate of operation except where noted)

1. Date ..... 2. Plant Name .....
3. Plant Location .....
4. Tons Coal Consumed per month .....
5. Seasonal Variations in Consumption .....
6. Coal Handling Cost per Ton, Active ..... Stored .....
7. Weight of Ash per day .....
8. Ash Disposal Cost per Ton Ash .....
9. Ash Disposal Method .....
10. Condition of Furnace .....
11. Boiler Scale Conditions .....
12. Burning Rate (Giving No. Boilers used with each Item):

			No. Boilers
a. Average Lbs. coal per hr.			
b. Maximum Lbs. coal per hr.			
c. Hours maximum load			
d. Hours banked			

13. Temperatures (Avg. °F.)

	Minimum	Maximum	Normal
a. No. Boilers on line			
b. Feed Water			
c. Air Supply			
d. Furnace			
e. Stack			

14. Draft (inches of water) .....
15. CO_2 (%) .....
16. Evaporation, actual Lbs. water per lb. coal .....
17. Efficiency (%) .....
18. Labor:
    a. Total No. men required to operate boilers per day .....
    b. Number of shifts .....
    c. Number of firemen per shift .....

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FORM IV

COAL EXPERIENCE

1. Date ..... 2. Plant Name .....
3. Plant Location .....
4. Sizes of Coal Suitable .....
5. Size Preferred .....
6. Is Ash Softening Temperature a ruling factor? .....
7. Description of Desirable Coal:
    a. Seam .....
    b. Shipping Point or Mine .....
    c. Moisture .....
    d. Volatile dry basis .....
    e. Fixed Carbon, dry basis .....
    f. Ash, dry basis .....
    g. Sulphur, dry basis .....
    h. B. T. U., dry basis .....
    i. Ash Softening Temperature .....
    j. Grindability:
        (1) Minimum Index .....
        (2) Maximum Moisture .....
    k. Washed .....
    l. Treated .....
8. Burning Characteristics:
    a. Coking .....
    b. Caking .....
    c. Free burning .....
9. Does Flame impinge on water cooled surface of boiler? .....
10. Where? .....
11. Percent Combustible in Ash .....
12. Troubles (at Maximum Operation):
    a. Lack of Steam .....
    b. Clinker .....
    c. Smoke .....
    d. Slagging .....
    e. Heating in Storage (at normal operation) .....
    f. Freezing .....
    g. Dust .....
    h. Fly Ash .....
13. Coal Satisfactory .....
14. Coal not Satisfactory .....
15. Coal Preferred .....

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FORM V

COAL TRIAL

Shipper ..... Seller .....
Mine ..... Seam .....
Capacity ..... Preparation .....
Location ..... District .....
Price ..... Frt. Rate ..... Dlvd. Cost ..... Cost Per Million B. T. U. .....
No. Cars Shipped ..... Size ..... Condition .....
Date Burned—From ..... to ..... Time in Transit .....

ANALYSIS

	As Received		Dry	
	Shipper's	Laboratory's	Shipper's	Laboratory's
1. Moisture				
2. Volatile				
3. Fixed Carbon				
4. Ash				
5. Sulphur				
6. B. T. U.				
7. Initial Softening Temp.				
8. Fusing Temperature				
9. Fluid Temperature				
10. Grindability				

OPERATING DEPARTMENT REPORT

Boiler No. ..... Avg. Rating ..... Peak Load 15 Min. ..... Pressure .....
Air Supply Temperature ..... Rating Comment .....
Pulverizer / Stoker | Condition ..... Amp. ..... K. W. per Ton .....
Firing Material .....
Condition of Furnace Before Run ..... After Run .....
Condition of Bottom ..... Walls ..... Tubes .....
Evaporation Actual ..... F & A ..... Character of Ash, % Combustible ..... Type of Clinker .....
Cin ..... Steam Cost—Coal ..... Total Steam Cost ..... Coal Classified .....

COMMENTS

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Operation of Steam Plants in Combined Steam and Hydro System

By A. T. HUTCHINS and HOWARD DURYEA
The Commonwealth & Southern Corp.

Following are excerpts from a paper at the A.S.M.E. Spring Meeting, Birmingham, Ala., in which the authors review the southeastern system of The Commonwealth & Southern Corporation, comprising numerous steam and hydro plants. The steam capacity, which has been expanded greatly during the past few years to meet the demands of war loads, is described briefly and operating procedure noted.

TERRITORY served by the southeastern group of The Commonwealth & Southern Corporation is shown in Fig. 1, which, because of lack of space, does not include all existing steam and hydroelectric plants, nor all of the transmission lines and substations. The data here presented refer to the system shown, corrections having been made for periods prior to 1940, when the Tennessee Electric & Power Co. was included in this group. The present system includes South Carolina Power Co., Georgia Power Co., Alabama Power Co., Gulf Power Co., and Mississippi Power Co., listed in order from east to west.

Fig. 2 shows total load, expressed in million kilowatt-hours annually, together with hydro and steam generation, and also peak hour maximum demands expressed in kilowatts, and installed capacity of hydro and steam sources. Purchased energy is not shown. Depression loads are apparent from 1929 through 1934, followed by moderate increases in 1937. Loads near the close of 1937 and 1938 decreased, following which they again increased and assumed the later sharp upward slope, characteristic of war production. There have been no increases in installed hydro capacity since 1930 and steam capacity also remained practically constant until war loads approached existing capacity about 1939 and resulted in construction of additional steam facilities. At that time the first of the units shown in the table was purchased.

The total capacity of run-of-river plants is around 375,000 kw and that of the two principal storage groups is 350,000 kw, making the total installed hydro capacity some 725,000 kw. However, the annual generation from this source is roughly two-thirds from run-of-river plants and one-third from storage plants. Total equivalent energy in storage is 450 million kilowatt-hours, with some additional 15 million kilowatt-hours in run-of-river ponds.

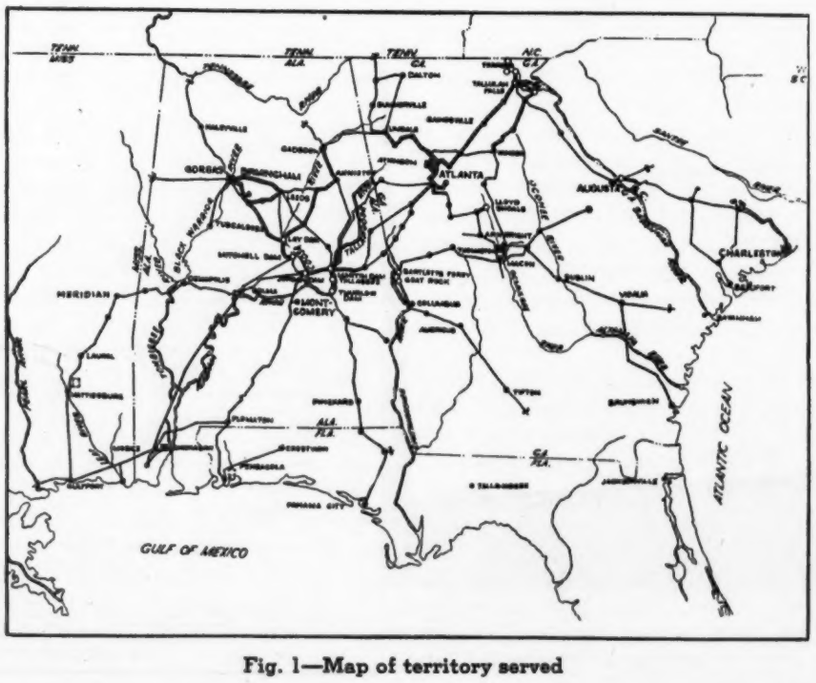

Fig. 1—Map of territory served

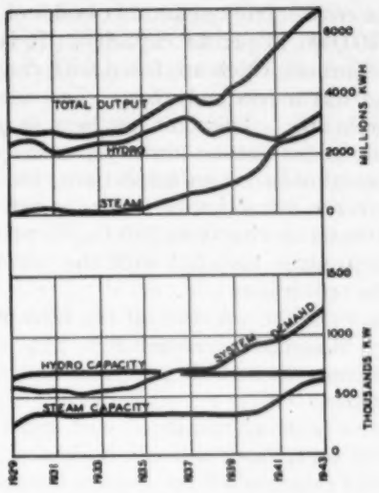

Fig. 2—Output and capacity curves

Although generating and transmission facilities, as well as distribution systems, are owned by the operating companies in the several states, planning, studies for additions, design engineering, and subsequent direction of operations of power sources are coordinated by a service company mutually owned by the operating companies. The personnel of the service company for the southeastern group is located in Birmingham.

Operation of all generating plants and the interchange of energy between companies within the group and with adjoining concerns is under the supervision of a central supervisory group of the service company, who work with the load dispatching forces of the individual companies. Hourly load estimates for the entire group are maintained constantly and are projected into the future to provide hourly load schedules for hydro groups and steam units during critical daily and week-end periods. Arrangements are made to load and unload steam units so as to utilize, supplement or conserve hydro flows;

STEAM CAPACITY ADDED SINCE 1941

Plant	Unit No.	Kw Rating	Throttle Pressure, Psi	Steam Temperature, F	R.P.M.	Generator Cooling	Initial Operation
Arkwright	1	40,000	850	900	3600	Hydrogen	April, 1941
	2	40,000	850	900	3600	Hydrogen	May, 1942
	3	40,000	850	900	3600	Hydrogen	Nov., 1943
Chickasaw	1	40,000	850	900	3600	Hydrogen	April, 1941
	2	40,000	850	900	3600	Hydrogen	March, 1943
Atkinson	2	60,000	425	750	1800	Air	Sept., 1941
Gorgas	5	60,000	850	900	3600	Hydrogen	Dec., 1943

provide for outages for inspection, maintenance and emergencies of steam and hydro units; and insure sufficient free hydro regulating capacity for tie-line control, spinning reserves and minimum flows when and where required. Arrangements are made to receive energy from outside sources and to make deliveries to them and to synchronize these transactions with hydro and steam operations on the system.

Older plants, which have become obsolete, may be useful for low annual use factors, even if the fuel and operating cost is from 3 to 5 times that of modern plants. In the past, the principal use of such older plants occurred in years having extreme low flows, when they had been assigned to base load operation for a few weeks. With the existing high loads the economic value of such secondary sources is much less, except as they may be utilized to replace large units where there have been emergency failures.

Fuel-burning plants during depression years fell into the category of secondary plants. During such periods the protection of buildings and structures against the weather, rotating machinery against absorption of moisture and rust, and boiler surfaces against corrosion both inside and out, became the principal problems. Bearing caps were lifted, bearings and journals oiled or greased, and rotors occasionally turned. Windings of generators and large motors were maintained above the dew point by heating elements, and in some instances it was found practical to maintain boiler steel a few degrees above room temperature by use of heating elements.

In contrast with the requirements on the steam plants and the minimum of operation and maintenance during these periods, when the output from the hydro plants was such a large proportion of the total load, we have now arrived at a situation in which the more efficient steam plants operate at maximum output for long periods.

Since the short hourly peaks throughout the year are carried by the hydro plants, the units listed in the table

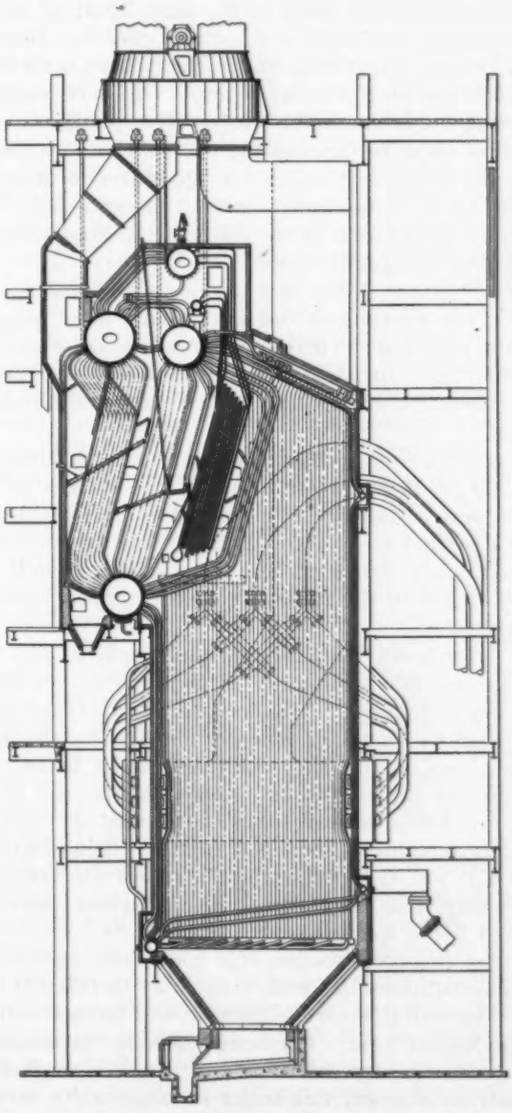

Fig. 3—Three of these units were installed

were all designed on the basis of carrying pre-scheduled loads. The extensive transmission system interconnecting the load areas with their steam plants, makes conditions ideal for the unit principle of design, in which one boiler supplies all the steam requirements for one turbine. One exception is Unit No. 2 at Plant Atkinson, where there was some capacity available in existing boilers. Because of the importance of the load in the local area a cross-connection was made between the steam lines of the two units at the Chickasaw Plant. It may be noted here that at the Gorgas Plant the steam conditions for No. 4 Unit are 425 psi and 750 F and No. 5 Unit 850 psi and 900 F, and no pressure-reducing and desuperheating equipment was installed.

The early plants in the 900-psi class were designed for 900 psi in the boiler drum and 850 psi at the turbine throttle. The design of superheaters to secure 900 F total steam temperature resulted in approximately 50 psi drop across the superheater at full load. When operated with a margin of 30 psi under popping pressure, and 20 psi drop through valves and piping, the pressure at the turbine approached 800 psi. In 1939 the requirement for safety valves designed to operate between 900 and 1500 psi was realized, and the purchase of the safety valves for the first boiler of the units listed in the table was delayed until such a valve was offered. Since that date boilers in this class have usually been built for 950 to 1000 psi at the boiler drum. This has resulted in securing the minimum of safety-valve operation.

All of these turbines in the 900-psi class are designed for four-stage extraction for feedwater heating, one heater being of the direct-contact type arranged for very complete deaeration of the feedwater. Feedwater temperatures are approximately 375 F.

Obviously, with the unit system the availability of the boiler for continuous operation over long periods is highly essential. Therefore, conventional types were selected and furnace design provided for reasonable heat liberation on the basis of four water walls and a dry ashpit.

Fig. 3 is a cross-section of a unit rated at 400,000 lb per hr, 950 psi drum pressure and 900 F. Three of these units were installed. Their furnaces have fin tubes on four sides and are tangentially fired with twelve burners, three at each corner. These three boilers, as well as the others listed in the table, are each equipped with three pulverizers.

A later boiler built for the same capacity and steam conditions differs primarily in the furnace bottom and the side-wall tubes. This has a hopper furnace bottom intended to safeguard against damage to the hearth tubes from falling slag, which occurred in the other design and it also affords better protection for the dry ashpit. Also, the wall tubes of this unit are 3-in. O.D. on $3^1/_8$-in. centers, each pair of tubes being bifurcated into a $3^1/_4$-in. O.D. tube which is rolled into the header. Obviously, this results in a cooler furnace, which has proved to be less subject to slagging.

Fig. 4 is a cross-section of a boiler built for the same steam conditions but with a capacity of 600,000 lb per hr. The wall tubes are bifurcated and furnace bottom is of the hopper type. The design embodies an economizer and omits the dry drum. As in the case of those previously mentioned, this boiler is tangentially fired and all five units regenerative-type air preheaters.

Fig. 5 is a cross-section of another boiler of the 900-psi class and 400,000 lb per hr capacity. It is fired with six circular burners which are fitted with rings for burning gas and has a relatively large economizer and tubular air preheater. This unit has been in service only a short time, and it is too soon to report on several features of operation based on inspections, but tests show that carryover is a fraction of 1 ppm at rated load and with boiler water having from 340 to 835 ppm dissolved solids. This unit is installed with the primary air fan ahead of the pulverizers.

The reason for the selection of the later boilers with economizers, designed to secure 2 to $2^1/_2$ per cent increased efficiency is that they will be assigned a more nearly base load.

All of these units are arranged with bypass dampers for control of superheat temperature, so that at from 60 to 100 per cent rating 860 F total steam temperature may be maintained. These dampers are manually controlled and for the type of load carried this has proved satisfactory.

The availability of burners and pulverizers installed

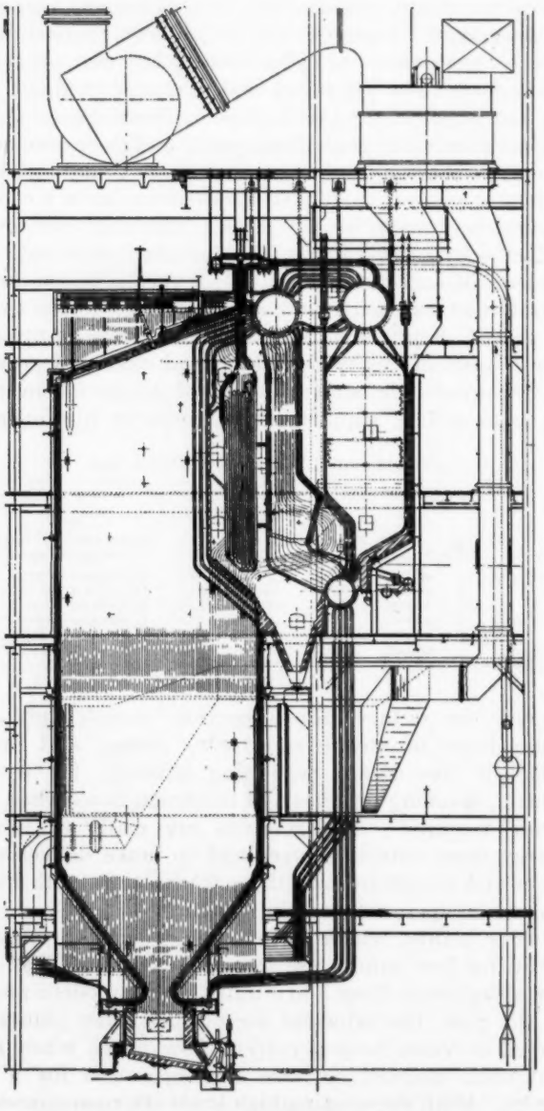

Fig. 4—Section through 600,000 lb. per hr. unit

with these units has been practically 100 per cent with no emergency outage. For the first 150,000 tons per mill when pulverizing coal having a grindability of 45 to 50, there have been no replacements with the exception of exhauster fan blades.

None of these superheaters are drainable and care must be taken to see that all condensed steam is evaporated from them before the tubes are subjected to gases at normal operating temperatures. One such failure has been experienced. As to the time element necessary to secure safe starting, it may be noted that, in general, the elapsed time between the first indication of pressure rise in the boiler drum when starting from cold and the time for closing vent valves on the superheater outlet when steam is being supplied to the turbine is approximately $2^1/_2$ hr. Other failures of superheater elements have been due to erosion, leaking baffle, and one case of corrosion.

Automatic combustion control providing only for the control of fuel and air to the pulverizers, secondary air supply, and induced-draft fan operation has been highly satisfactory.

With one exception, the pumps for these units are all motor-driven with constant-speed motors and the feedwater control element consists of a single valve. Something over two years' service from one of these valves, which is provided with good hydraulic characteristics, has resulted in an almost perfect record, and the valve is now reported as being tight enough for shutoff purposes so that the boiler may be banked with a full pressure on the pump side of the valve. In contrast with requirements for boilers supplying steam at a rapidly fluctuating rate where three-element control is used, these valves operate from drum level only.

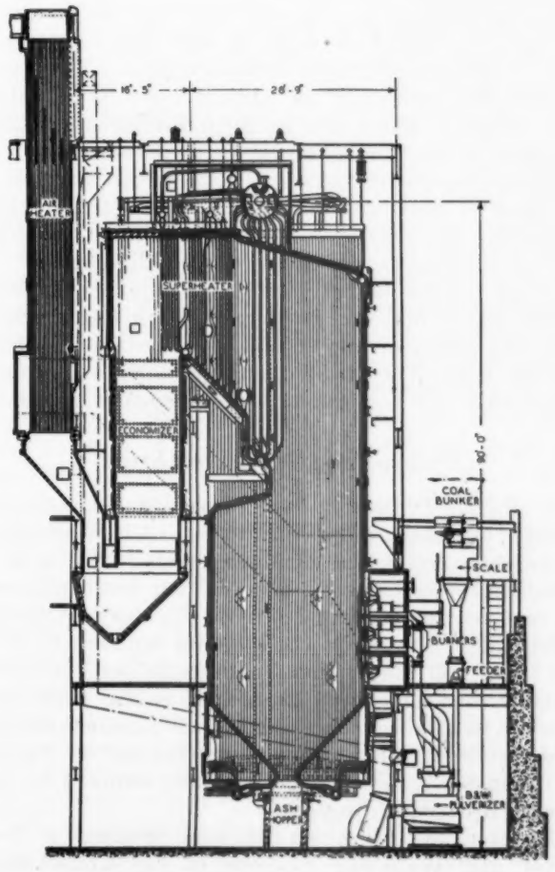

Fig. 5—Cross-section of latest unit

By using a direct-contact heater for deaerating the feedwater and as a storage supply ahead of the boiler feed pump, one high-pressure closed heater has been eliminated. On the other hand, power for pumping increases somewhat and it has been found that pure water at 320 F attacks the steel in the pump more rapidly at points of high turbulence than at 235 F, as frequently used. The cure for this has been coating such areas with a high-grade alloy metal or some recirculation of boiler salines.

Although the history of these units is not long enough to be conclusive in regard to carryover, turbine Unit No. 1 at Chickasaw and No. 2 at Arkwright were each inspected after two years' operation and were found to be relatively free of blade deposits. In fact, this condition was such that continued operation throughout another year would have been satisfactory in this respect.

In order to secure feedwater having low content of dissolved solids, makeup is provided from evaporators and special attention has been given to assure tight condensers. Two methods are used in securing condenser tubes to the tube sheet. In one the tubes are rolled at both ends and bowed slightly to take care of expansion; and in the other the tubes are rolled at one end and packed at the other end which is highly polished to avoid dragging the packing in movement due to expansion. Both methods have proved highly satisfactory.

Starting with high-grade condensate, water is supplied direct to the boilers without the addition of chemicals but with thorough deaeration. Chemicals are supplied individually to each boiler through a chemical feed pump and the initial operation of all boilers has used phosphate treatment. Enough sodium sulphite is used to maintain from 10 to 15 ppm in the boiler water in order to take care of any residual oxygen or that picked up during shutdown periods. It may be noted here that the record of sulphite used shows considerable discrepancy between 450 lb and 850 lb pressure. The easiest explanation is that with the higher pressure some of the sodium sulphite is broken up. About 15 or 20 ppm PO-4 in solution is maintained in the boiler water and a pH of approximately 11. Under these conditions it was found that the first three boilers installed accumulated a considerable amount of fine black magnetic oxide in the boiler water. This oxide was present in quantities sufficient to cause considerable concern but remedial measures have been delayed because of the necessity of maintaining all boilers in operation. Some variation in boiler water treatment was undertaken but without conclusive favorable results. Although no boiler failures have resulted from this type of corrosion, its prevention will be eagerly sought.

Six of the seven turbine-generator units installed in the last four years are equipped with hydrogen cooling.

It may be said that all changes in equipment, worked out through cooperation with the manufacturers during the design of these plants, have been quite satisfactory. Shortage of manpower of every class has prevented the compilation of data to determine very closely the performance of these units, but such checks as have been made indicate that they are surpassing design performance.

A.S.M.E. Spring Meeting at Birmingham

GOOD attendance and a well-balanced program marked the Spring Meeting of the A.S.M.E. at Birmingham, Ala., April 3 to 5. Aviation, war production and power topics, some relating to the South, accounted for the majority of the papers a few of which are here reviewed briefly.

T. C. Cheasley outlined the Federal Fuel Conservation Program which is now getting under way, patterned somewhat after the plan that has proved very successful in England. In this connection he showed a number of motion pictures demonstrating the educational work there being carried on in many plants.

Stoker Fuel-Bed Studies

"The general impression, when looking into a stoker-fired furnace, is that the fuel bed is motionless, incandescent and active. While the actual motion is very slow, nevertheless, it is positive and regular. The slowness makes it difficult for the human eye to see, follow and remember successive steps during any given cycle. Furthermore, there are distractions due to intensity of illumination, eye fatigue and sudden occurrences in sections of the furnace other than the one under observation. Consequently, to have a true picture of sequence of operation and resulting changes, the action must be speeded up. The amount of speedup cannot be accomplished by simply running the stoker faster, even if it were possible to reduce the intensity of illumination, because action would still be too slow. Furthermore, conditions that would be developed are not representative of those at normal rate of operation.

"Another difficulty encountered in trying to set up or reproduce certain fuel-bed action is that no two observers see the same sequence of occurrences unless there is ample repetition. As a result, there may be differences of opinion as to cause and effect, and considerable time may be lost in arriving at designs or changes required to produce desired results."

With the foregoing introduction **Otto de Lorenzi,** Director of Education of Combustion Engineering Company, proceeded to show a number of motion-picture films in Kodachrome of fuel beds with several different types of stokers. By speeding up these films he demonstrated how within a few minutes, a comprehensive analysis is possible of what happens over long periods. In doing so he pointed out the effects of various factors in design and operation. The speed-up pictures he characterized as a most valuable tool for studying stoker operation as a basis for design.

Mr. de Lorenzi also reviewed briefly the working of standard types of stokers and the fuels to the burning of which they are best adapted, at the same time giving many helpful operating suggestions.

Oblique Radiation on Boiler Tubes

Lt. Commdr. W. S. Kimball, Marine Engineering Department, U. S. Naval Academy, contributed an analysis covering temperature distribution within boiler tubing under oblique radiation. This amplified studies previously made by Dusinberre, Davidson, Faurier and others dealing with radiation normal to the tubes, and served as a check on results obtained by certain simpler methods which are sometimes employed. In other words, a general mathematical expression was evolved for temperature distribution under parallel radiation at any angle with the boiler wall normal.

Graphs were included for four typical cases, namely: (*a*) where 120 deg of the tube surface is exposed to radiation of exactly three-fourths the amount of normal heat radiation; (*b*) where 90 deg of the tube surface is exposed, receiving just half the amount of normal radiation per tube; (*c*) where 60 deg of tube surface is exposed, receiving one-quarter the normal radiation per tube; and (*d*) where 30 deg of tube surface is exposed.

For the 120-deg exposure, the radiation comes in at an angle of 41 deg 25 min with the boiler wall normal; for 90-deg exposure, the radiant heat comes in at an angle of 60 deg; for 60-deg tube exposure the angle of obliquity is 75 deg 30 min; and for 30-deg exposure, or one-sixth the tube surface, the angle is 86 deg with the boiler wall normal.

The temperature graphs show that the hot point of highest temperature is not where the oblique radiation comes in normal to the tube surface, but is shifted back toward the symmetric point opposite the fire cavity where the tube surface parallels the boiler wall. This hot-point shift occurs in the direction of the geometrical center of the received radiation.

An interesting fact is the way the temperature gradient, or difference between the outer and inner tube surface temperatures, falls off with increased angle of obliquity, assuming the same density of radiation. For instance, where the received radiation is three-quarters of the normal radiation, and comes in at an angle of 41 deg with 120 deg of tube surface exposed to it, there is only a 2 per cent drop in temperature gradient. The distribution is merely shifted around the tube in the direction of the received radiation.

These results indicate that ease or efficiency with which heat is disposed of decreases with the increased obliquity angle, since the shortage of heat supply from the fire falls off with increasing obliquity angle much faster than the corresponding temperature gradients.

Pulverizer Maintenance

A Panel Discussion on pulverizer maintenance brought out many points of interest. A representative of the Alabama Power Company stated that with 55 grindability coal maintenance on their bowl mills was $^{3}/_{4}$ cent per ton as compared with $1^{1}/_{2}$ cents per ton for roller mills. Inasmuch as the power required to drive the bowl mill may increase up to 20 per cent after 150,000 tons have been ground, it is the company's practice to balance power cost against maintenance cost in determining when to renew wearing parts. The life of exhauster blades had been almost doubled by employing distributor rings.

Maintenance of pulverized coal systems at East River and Waterside Stations of the Consolidated Edison Company were compared. The former, em-

ploying a storage system and roller mills, showed a cost of about 12 cents per ton, a large part of which was attributed to the conveying system. At the latter plant, maintenance on the bowl mills is about 5 cents a ton, this relatively high figure being due to the necessity of doing the work over weekends with the consequent high over-time rates for labor applying. Moreover, taking advantage of the operating cycle, it is customary when a mill is down to renew all parts showing wear even though there may be many hours use left in the part.

At one plant of the Tennessee Coal and Iron Company, experience with roller mills has shown 50,000 tons per set of rolls and 12,000 tons for the exhauster; whereas at another of its plants using bowl mills and coal of 20 per cent ash the life of the rolls is 50,000 tons, that of the exhauster blades 8000 tons and that of the exhauster liners 12,000 tons.

Another company finds that the exhauster blades wear more on one side, hence this side only is replaced.

Operation of Hydro and Steam Capacity

G. W. Spaulding, vice president of the Pennsylvania Water and Power Company, contributed a comprehensive paper dealing with the coordinated operation of hydro and steam power plants in the Middle Atlantic States of New Jersey, Delaware, eastern Pennsylvania, Maryland and the District of Columbia. This section is served by seventeen or more electric utility systems representing a generating capacity of over 4½ million kilowatts. Interconnection between the northern and southern parts of this area began in 1931 and more recently interconnections have been strengthened between the northern end of this regional power group and other systems in New York State and New England.

The regional area first mentioned is predominantly urban in character and the capacity is approximately 85 per cent steam and 15 per cent hydro. Of the effective hydro capacity of about 670,000 kw, nearly 90 per cent is installed in run-of-river plants along the lower reaches of the Susquehanna River, about 8 per cent is supplied from storage projects in the Delaware River drainage basin, and the balance is made up of numerous small hydro installations. The Susquehanna is subject to wide variations in flow, the recorded minimum being less than 5 per cent of the usable flow at the Safe Harbor Plant and the maximum flood was nearly fifteen times as great as the usable flow. While the flood stages usually occur in the spring and the resultant reductions in head and capacity rarely adversely affect system capacity requirements, the low flows in late summer, fall and winter do affect system capacity. Mr. Spaulding then explained how this situation is normally handled with both hydro and steam taking their respective shares of the peak loads.

The situation, however, has been altered by war-time loads with the result that it has been necessary to use all steam capacity on a more or less sustained basis and those plants that were designed primarily for peak operation must be operated for longer periods at reduced loading; with the sharp peaks being carried by hydro under critical capacity conditions.

Mr. Spaulding pointed out that there are several essentials to complete and full coordination of the combined generating facilities of a regional power system, in addition to the necessary physical facilities. The first of these is the availability of power contracts or interconnection agreements between the several companies in the area, which must be sufficiently flexible to cover a wide range of operation. Secondly, considerable operating experience is necessary before the fullest advantage from coordinated operation can be obtained. The third essential is a procedure for day-to-day direction and control of coordinated operation.

After describing the installations in this area; discussing the load curves, maintenance requirements and seasonal reductions in steam capacity; the paper concluded with the observation that "The coordinated operation of all the interconnected utilities in this regional system, initiated by the utilities themselves for economic reasons, even before the war clouds gathered in Europe, has proven of immense value in meeting electric power demands in the national war effort. There has been considerable satisfaction in the realization that the saving of fuel and its transportation has been accomplished and that the area has been able to absorb increased war loads because of such coordinated operation on a regional system basis."

A second paper on this general subject but dealing particularly with steam capacity on the Commonwealth & Southern southeastern system, by Messers. Hutchins and Duryea, is more fully abstracted elsewhere in this issue.

Adjustable-Blade Pumps

A new approach to the problem of pumping large quantities of water under wide variations of head, by employing adjustable-blade pumps was reviewed in a paper by **J. D. Scoville,** Asst. Chief Engineer of S. Morgan Smith Company. The particular installation under discussion involved the dewatering of two large naval drydocks, each requiring the handling of approximately 60 million gallons of water in a period of 100 min. One dock was equipped with four 1250-hp pumping units and the other with three 1500-hp units. The estimated head varied from 15 to 55 ft.

While adjustable-blade features have long been employed with hydraulic turbines, their application to pumping service is comparatively recent.[1] Therefore, a model was first constructed and subjected to laboratory tests for efficiency and cavitation. Several sets of curves from these tests were shown.

In comparing this type of pump with the conventional types, Mr. Scoville pointed out that near the end of the pumping period neither the fixed-blade propeller nor the mixed-flow pump can control the discharge as readily as can the adjustable-blade type. The fixed-vane pumps must be shut down one at a time as the depth reaches a level where the water flowing down the dock can no longer keep up with the pump discharge. Eventually the point is reached where the capacity of one pump is too great and the final volume of water must be removed by small capacity drainage pumps. On the other hand, the adjustable-blade pump can control the flow until the floor is practically dry. Moreover, by varying the blade position a constant load can be maintained on the motor.

[1]The first application of such pumps for condenser circulating water was at the Venice Plant of the Union Electric Company of Illinois which was described by L. N. Reeve and J. D. Scoville in COMBUSTION, May 1943.

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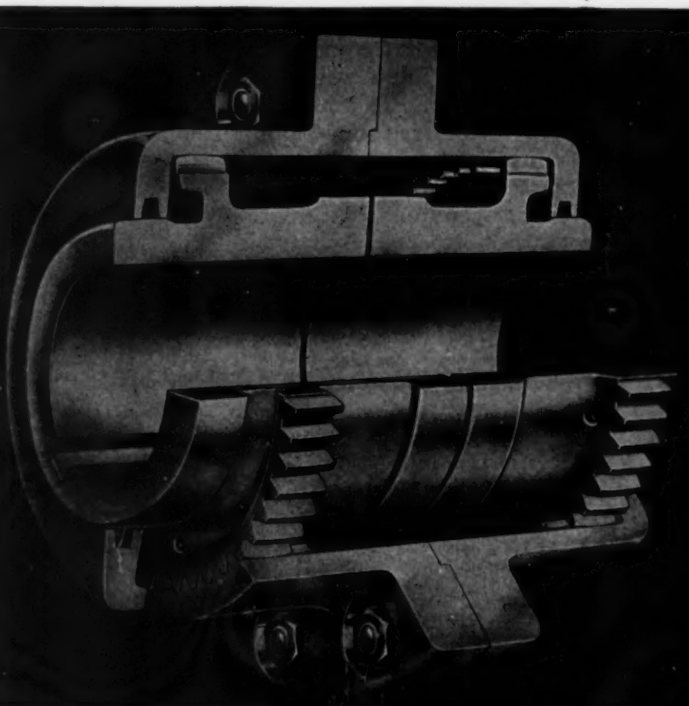

A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

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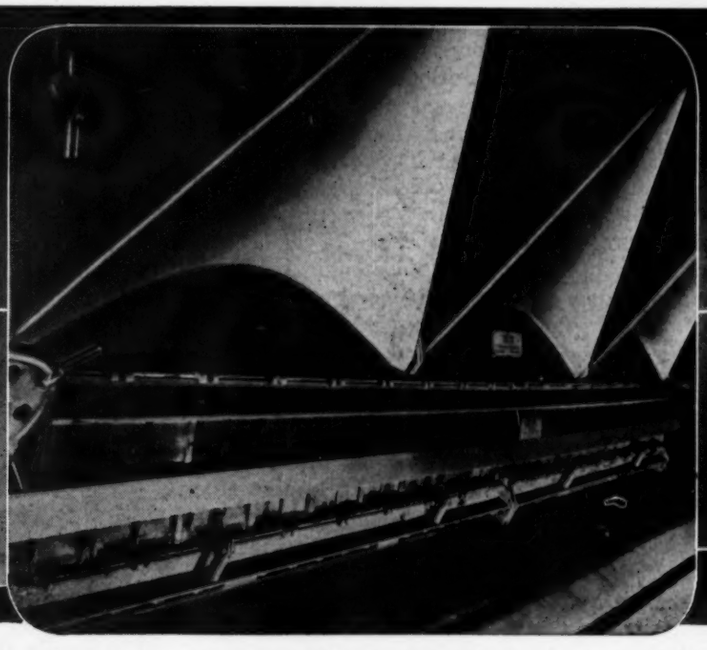

● "Real Estate"—fine black or clay dirt bears resemblance to some war-time coals that have not been as thoroughly cleaned as either the producers or users would like. This material sticks in chutes, scales, and valves—hence operating troubles and still more operating troubles. Have you had these difficulties yourself this winter? If so, a properly designed "Bunker to Stoker" or "Bunker to Pulverizer" installation may prove to be a solution to part of your troubles. Why not check with the Stock Engineering Company, 9803 Theodore Ave., Cleveland, Ohio?

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Heine Division of Combustion Engineering Wins Maritime Award

The U. S. Maritime Award consisting of the Maritime "M" Pennant, the Victory Fleet Flag and Merit Badges for employees were presented to the Heine Boiler Division of Combustion Engineering Company at St. Louis on April 3 in recognition of the production record of that plant in supplying equipment for the wartime shipbuilding program.

A. D. MacLean, Director of Production of the U. S. Maritime Commission made the presentations of both the "M" Award and the Merit Badges. The former was accepted by F. O. Pahmeyer, General Manager of the Heine Boiler Division and the latter by C. J. Phelan and Dolsy Walls, on behalf of the shop employees.

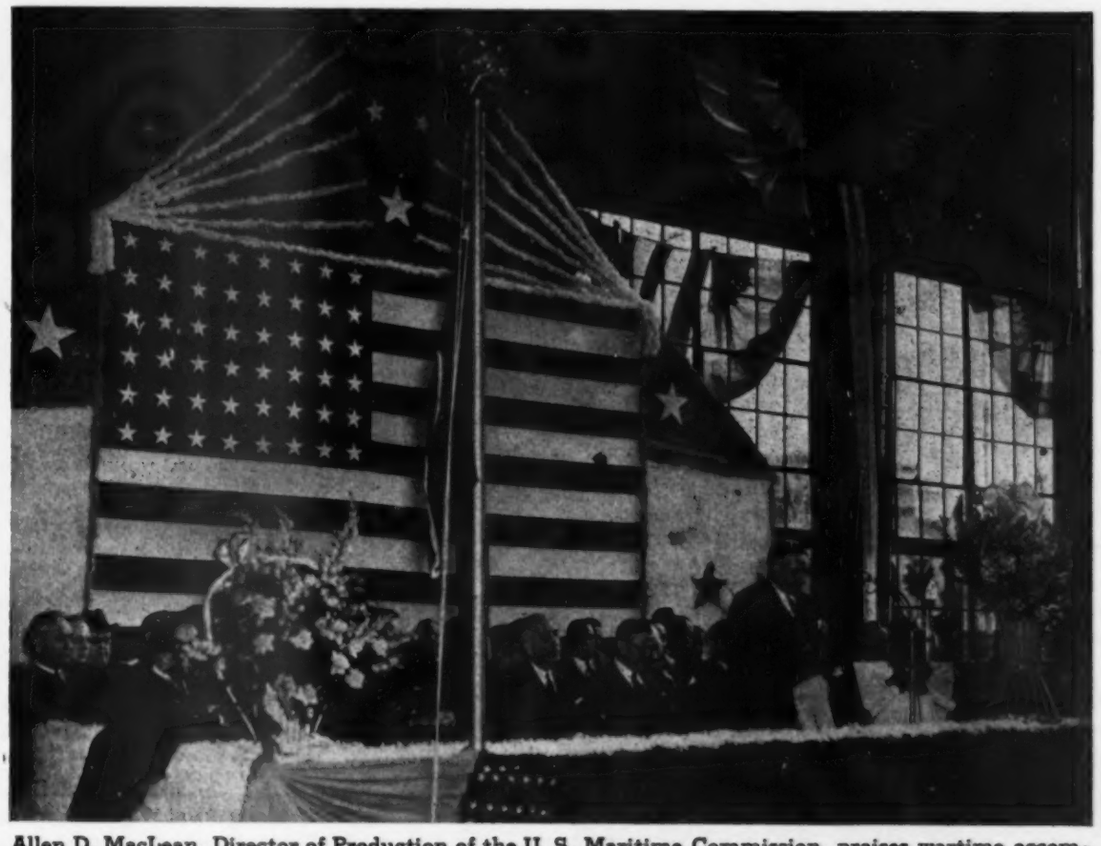
J. V. Santry, President of Combustion Engineering Company, expressed the Company's appreciation of the Award. Addresses were made by Mayor A. P. Kaufmann, of St. Louis, and by Comdr. J. K. Galleher, administrative officer of the Merchant Marine Cadet Corps Academy. M. D. Stone acted as Master of Ceremonies and music was furnished by the 523rd Army Air Forces Band.

In his presentation address, Mr. MacLean stressed the paramount importance of shipping and the maintenance of marine supply routes. Each soldier overseas requires about seven tons of material on landing and two and a half tons per month thereafter. If we consider the number of men eventually required overseas, we will realize what a tremendous undertaking it is to supply munitions, food and other equipment for our fighting men. To meet these demands, the Maritime Commission was asked to build 8,000,000 dead-weight tons of shipping in 1942, and over 19,500,000 tons, including auxiliary and military craft in 1943. These objectives were met and exceeded.

"During these two years there were completed 2642 ships, totaling more than 27,000,000 dead-weight tons. Ships originally scheduled to be built in 105 days are being built today in an average time of 45 days. During the first three months of this year, our shipyards turned out 410 ships, which swells the total since Pearl Harbor to 3061 ships."

Mr. MacLean warned his listeners against "over confidence" and tried to impress on management and labor alike that the task to be done requires much more energy and effort and time and sacrifice than any task ever before presented to this country. He praised the performance of the Heine Boiler Division of Combustion Engineering Company in meeting on expedited schedule and in producing at a rate to keep up with the shipways in producing ships. "Firms like yours who do the unusual—firms who go beyond the expected production—are the backbone of the Maritime Commission's success," he said.

Incidentally, the Hedges-Walsh-Weidner plant of Combustion Engineering Company was recently awarded the third star for its "M" Pennant and the Company's Assembly Plant at Savannah, Ga., was awarded the Army and Navy "E" for work in pre-assembling boilers for destroyer escort vessels.



Allen D. MacLean, Director of Production of the U. S. Maritime Commission, praises wartime accomplishments of the Heine Boiler Division of Combustion Engineering Company at presentation ceremony of Maritime Commission Awards on April 3 at the Company's plant, St. Louis, Mo.

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Dustless Treatment of Coal With Oils Now Available

Following a period of eighteen months during which the use of oil or other petroleum products for the dustless treatment of coal was prohibited, Petroleum Distribution Order No. 13 was amended to permit the use of Nos. 5 and 6 and Bunker C fuel oils having A.P.I. gravities of 20 deg or lower. Inasmuch as the characteristics of these oils are quite different from those previously employed for coal spraying, Battelle Memorial Institute, Columbus, Ohio, has just issued a bulletin containing answers to a number of questions concerning the use of these oils. Although the information was compiled primarily for the use of the coal industry, much of it is also of interest to the consumers. Following is a digest of some of the points covered:

The coal-spray oils previously employed were of uniform viscosity, flash point and pour point, with negligible odor; whereas those now permitted are generally characterized by low flash point, high pour point, wide range of viscosity, and commonly have objectionable odor.

Viscosity governs to some degree the amount of oil required for spraying and to a larger extent the permanence of the treatment. Moreover, the required viscosity varies with the rank and inherent moisture content of the coal. For example, with low inherent moisture coals, as from the eastern fields, a Saybolt-Universal viscosity of 100 sec may be satisfactory; whereas a low-rank coal of high inherent moisture, such as some of the midwestern and western coals, require a viscosity of at least 600 sec and in many cases higher. Most of the eastern coals do not require an oil having a viscosity higher than 200 sec. No. 5 oil may have a Saybolt-Universal viscosity as low as 50 sec and Bunker C fuel oil as high as 3000.

Whereas a flash point of 300 F was previously recommended as the minimum acceptable for coal spraying, No. 5 oil will range as low as 130 F, and No. 6 and Bunker C oils as low as 150 F. For safety the flash point should not be lower than the temperature to which it is heated for spraying. Low flash point is usually accompanied by objectionable odor.

Coal-spray oils previously available usually had pour points of 0 F and often as low as −30 F, but the pour points of those now permitted are rarely as low as 10 F and may be as high as 50 F.

Necessary Precautions

With reference to the precautions necessary in using fuel oils for dust-proofing, it is recommended that the thermostatic control be set to a temperature at least 20 deg F lower than the flash point; that no open flame be permitted near the oil spray; and that no accumulation of oil-soaked coal dust be permitted in the tipple.

Except in severe winter weather, it may be possible to use oils having a viscosity of 200 sec in cold-spray systems if steam coils are available to heat the oil in the tank cars or in storage.

Applications of oil to coal for dustless treatment have sometimes been made in the form of a mixture of oil and sawdust, in 50–50 proportion. In such cases oils of 200 to 600 sec viscosity have been successfully used. Tests have indicated that such mixtures are slightly more effective than oil alone.

The quantity of fuel oil required for spraying varies from one quart per ton of a hard-structure, well-screened, low-moisture coal in stoker size to as much as six or eight quarts per ton of high-moisture stoker coals or slack sizes.

These oils can be emulsified in water by the addition of suitable materials. Emulsions were widely used in the early days of oil treatment, but their use decreased because suitable atomizing equipment for oil alone was later developed. The effectiveness of these emulsions is about the same as that of their oil content because the water evaporates. If a coal is properly treated with one quart of oil per ton, the application of a 10-per cent oil emulsion at the rate of 2.5 gal per ton will give similar results in the reduction of dust.

Reclamation Plants Provide Large Output

Power production by the thirty power plants of the Bureau of Reclamation in 1943 attained a record of nearly twelve billion kilowatt-hours which represented an increase of 275 per cent in two years. Revenues received by the Government for this power amounted to approximately fifteen million dollars. Estimates for 1944 place the output at 31½ billion kilowatt-hours and an income of eighteen million dollars.

Installed capacity in the Bureau's plants at the end of 1943 totaled over two million kilowatts and projects cleared for completion during the present year will add about 340,000 kw. These are all hydroelectric plants and in most of the installations electric power is a by-product of reclamation projects.

Personals

A. C. Weigel, Vice President of Combustion Engineering Company, has been nominated for the Presidency of the American Welding Society.

R. S. Coffin has been elected President of Bailey Meter Company, succeeding E. G. Bailey who becomes Chairman of the Board. Mr. Coffin has been identified with the company since 1916.

W. E. Bisler has joined Dowell, Inc. as industrial engineer attached to its New York Office. Mr. Bisler was formerly for many years with Combustion Engineering Company and more recently was Pittsburgh District Manager for the Pomona Pump Company.

Pictured above is Sauerman Scraper System serving a large generating station where scraper stores and reclaims 200,000 tons of coal a year.

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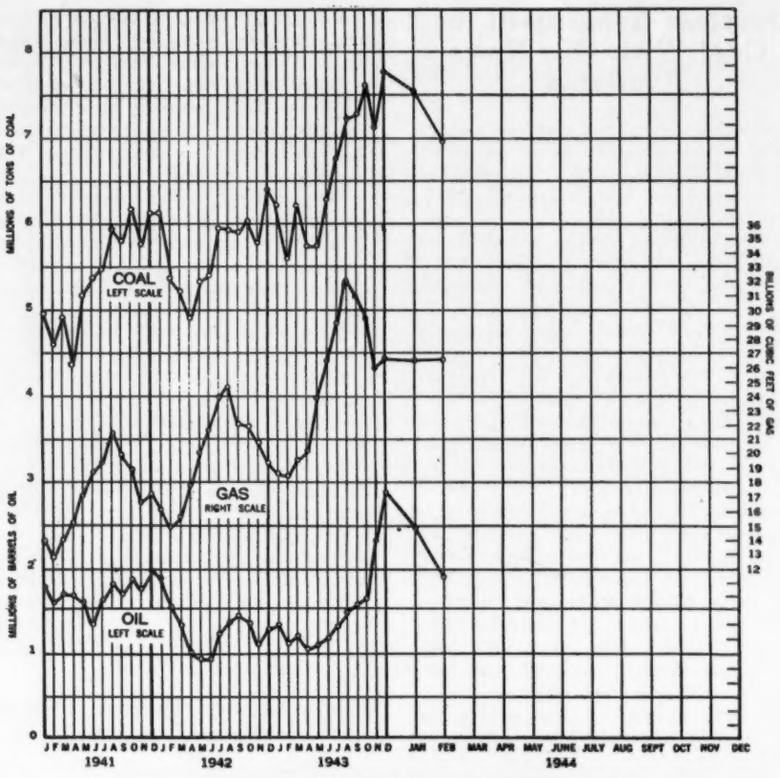
Current Power Statistics

As reported by the Federal Power Commission on April 4, the total electric energy produced for public use during the first two months of this year amounted to over 38 billion kilowatt-hours. This is approximately 15 per cent in excess of that for the first two months of 1943, whereas the production of 222,550,114,000 kw-hr for the twelve months ending February 29, 1944, was 17.1 per cent over that of a year previous. This would indicate that the peak has been passed, which is further borne out by the fact that the average daily production during February 1944 was 0.5 per cent under that of January. Fuel consumption also showed a decrease as indicated on the chart.

The capacity of generating plants in this category in service, as of February 29, 1944, was 49,459,220 kw which represented a net increase of over 206,000 kw during the month.

The same source reports that gross operating revenues of the major privately owned electric utilities in 1943 reached an all-time high of $2,969,475,000. Revenue from industrial power showed an increase of 15.3 per cent over 1942; that from residential service an increase of 4.4 per cent; and that from commercial service a slight decrease. On the other hand, operating costs were up and taxes increased 9.3 per cent to a total of nearly 674 million dollars, leaving a net income of 505 million dollars.


MILLIONS OF TONS OF COAL
MILLIONS OF BARRELS OF OIL
BILLIONS OF CUBIC FEET OF GAS
COAL
LEFT SCALE
GAS
RIGHT SCALE
OIL
LEFT SCALE
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
1941
1942
1943
1944

Consumption of Fuel for Production of Electric Energy

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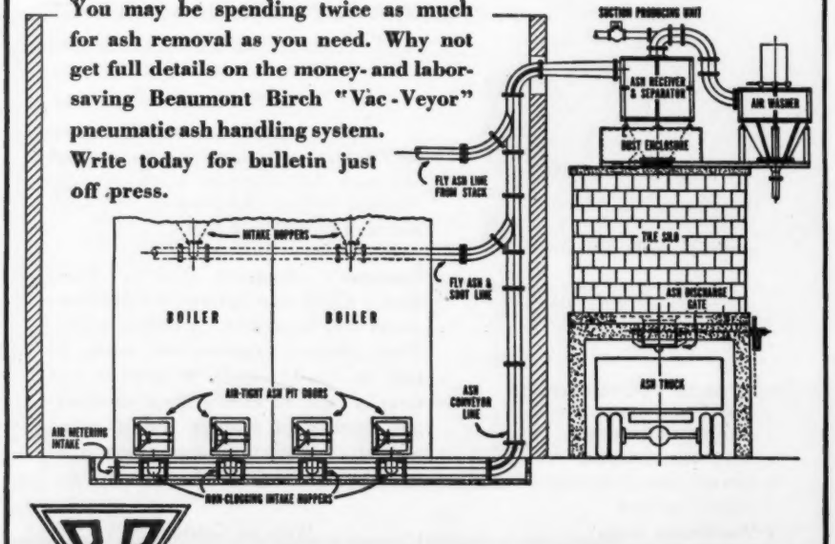

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The Heat Pump

Writing in the latest issue of *The Brown Boveri Review* (Swiss), A. Meldahl explains in an elementary way the working principle of the heat pump and discusses its efficiency. He points out that, fundamentally, there is no difference between a refrigerating machine and what he designates as a heating machine, but which is commonly referred to as a heat pump The former absorbs heat at relatively low temperature from the substance to be cooled, this heat being increased by that equivalent of the energy of compression and then dissipated at higher temperature. With the latter the low-head heat is absorbed from the air, water in a lake or river, or exhaust from process, and the high-head heat is given up to some useful purpose.

Heat engines, such as the steam engine, gas engine or steam turbine, convert heat into mechanical work; whereas the heat pump is essentially a reversed heat engine. This is based on the fact that it is possible, apart from certain losses, to reverse the thermodynamic process of the heat engine. That is, instead of the rejection of heat at the lower temperature, there is absorption of heat at low temperature and rejection at high temperature. The heat engine develops power whereas the heat pump absorbs power and gives up heat.

It is customary to express the performance of a heat pump as the ratio of the useful heat given up to the heat equivalent of the power absorbed. This ratio is called the *coefficient of performance* which may range from 3 to 6 where the source of heat is the surrounding temperature, or 10 to 20 where exhaust heat at more favorable temperature is available. The theoretical

maximum value of the coefficient of performance may be deduced from the Carnot equation, $\frac{T_1}{T_1 - T_2}$, but this cannot be achieved in practice; hence the actual efficiency of the heat pump is expressed as the ratio of the coefficient of performance to the Carnot efficiency. The actual efficiency will be affected by the drop of temperature in the heat exchangers, the working medium employed and the efficiency of the compressor.

With some processes it is possible, by means of a heat pump, to recuperate the latent heat of evaporation which would otherwise be lost and thus achieve high coefficients of performance. This is especially true when the steam produced serves as the working medium of the heating machine.

There follows in the same issue of *The Brown Boveri Review* a description and test results of a thermo-compressor installation in Lucens for the concentration of milk.

Planning for N.A.P.E. National Convention

St. Louis Association of the National Association of Power Engineers will be host to the National Convention of the N.A.P.E. to be held at the Hotel Jefferson, August 22–25. In conjunction with this meeting, the National Power show will be held.

A meeting was recently held in St. Louis, which was attended by National President Bland, National Secretary Thompson and past National Presidents F. C. Laufketter and Stephen Castile and the local committee. At this time the accompanying photograph was taken and plans were completed for the convention. Nationally recognized speakers will be in attendance; provision has been made for patriotic booths; and invitations to all recognized engineering societies have been extended and several have accepted.

Standing, left to right: Frank Laufketter, Tom Murphy, Herman Weber, Conrad Hemmersmeier, Frank Patton, Albert Froussard, A. F. Rieber, C. E. Chapman, Ferd Herr and Russell Loving
Seated, left to right: James A. Whitmer, Charles Herr, Wm. Warga, Stephen Gradl, J. S. Forman, National Secretary A. F. Thompson, National President C. A. Bland, National Past President F. C. Laufketter, National Past President Stephen Castile, President Mo. No. 2, Eugene Bishop, Frank Velton, Forrest Henn, June Froussard

George A. Orrok

George A. Orrok, widely known consulting engineer, died at his home in Riverside, Conn., on April 6 at the age of seventy-seven.

Born in Dorchester, Mass., Mr. Orrok attended both the Massachusetts Institute of Technology and Stevens Institute of Technology and, following some six years of design and construction work in the street railway and mining fields, he became associated with the New York Edison Company. In 1905 he was appointed its mechanical engineer. In this capacity he had much to do with the design of that company's several power stations. From 1914 to 1928 he was consulting engineer for the New York Edison Company and also had a hand in the design of several hydroelectric projects of affiliated interests. Upon severing connections with the company in 1928 he established a consulting engineering practice in association with David Moffat Myers and W. A. Shoudy.

Mr. Orrok did considerable research in the field of heat transfer, condensers and furnaces and was active in sponsoring research in the properties of high-pressure steam which gave him many contacts abroad. He also gave a course in steam engineering at Brooklyn Polytechnic Institute and was a well-known lecturer on mechanical engineering and power subjects.

He was a fellow of the American Society of Mechanical Engineers of which he had long been an active member and took a leading role in the Newcomen Society in which his historical interests found an outlet.

Surviving are his wife, Mrs. Elene Orrok, a son George A. Orrok, Jr., now with the Boston Edison Company, and a brother, Henry Orrok.

A. B. Williams Dies

Albert Blake Williams, Consulting Engineer, Stone & Webster Engineering Corporation, died at his home in Brookline, Mass., on March 29.

Mr. Williams was born in Jersey City, New Jersey, May 22, 1884 and graduated from Cornell University with the degree of M.E. in 1906. After several years in contract piping work, he entered the employ of the Interborough Rapid Transit Company, where he began his career in the field of steam power plant engineering. He rose rapidly to the post of Construction Engineer, and had charge of the design and construction of additions to the Interborough power stations at both 59th Street and 74th Street, which accompanied the great expansion of the New York subway system during that period.

In 1919 Mr. Williams became associated with Stone & Webster Engineering Corporation. He was in charge of the construction of many outstanding utility and industrial installations, including the South Meadow Station at Hartford, Connecticut, and the Edgar Station at Weymouth, Massachusetts, the latter being the first 1200-psi installation in the United States. In 1926 he became Chief Mechanical Engineer, and in 1929 he was appointed Assistant Engineering Manager in charge of the Mechanical, Power and Industrial Divisions; in 1941 he was given the title of Consulting Engineer. Mr. Williams was an authority on high-pressure piping, and in spite of the breadth and scope of his work in directing all of Stone & Webster's mechanical engineering designs for a number of years, he maintained an unflagging interest in that specialty.

He was a member of the A.S.M.E., the Cornell Clubs of Boston and New York, and Cornell chapter of Phi Kappa Psi. He is survived by his wife, Frederica Howell, and two children, Albert Blake, Jr., and Frederica.

REVIEW OF NEW BOOKS

Any of the books here reviewed may be secured through Combustion Publishing Company, Inc., 200 Madison Ave., N. Y.

Graphical Solutions (Second Edition)

By Charles O. Mackey

It is encouraging to note that engineering schools have taken a more active interest in the subject of graphical representation, and Professor Mackey is to be congratulated for his compilation of the various methods proposed by d'Ocagne, Lipka, Peddle and others.

The practicing engineer is often confronted with the problem of grasping the significance of complex formulas involving several variables; a graphical plot presents him with a pictorial view of the effect of each factor in the formula on the final quantity sought. In addition to showing the trend of the values involved, a graph often helps to point out the limits of applicability of the mathematical expression.

Four chapters of this book deal with Stationary Adjacent Scales, Sliding Scales, Network and Intersection Charts, and Alignment Charts. Empirical Equations are dealt with in two additional chapters, Non-Periodic Curves and Periodic Curves. The author disavows any intention of presenting a complete treatise, but the reviewer feels that a little more emphasis might have been put on the possible error introduced in reading a chart. It is obvious that the quantity read should be no more accurate than the experimental data from which the mathematical relation is originally derived. The choice of scale must then be suitable to the accuracy involved so that a scale need not read to the first decimal point if the test data only warrant that integers be included. The danger of obtaining a fictitious value is even greater with alignment charts because the variable interval scale is often set up for a different degree of accuracy at separate points on the scale.

To the man in industry the most beneficial aspect of graphical solutions is its time-saving feature. Indeed, one might speculate on how much of the present upsurge in the output of war goods is traceable to the use of graphical charts, which are constantly in demand in selecting equipment.

Professor Mackey's book is highly recommended as a valuable addition to the practicing engineer's library. It contains 152 pages, size $5^1/_4 \times 8^1/_4$, and is bound in black buckram. Price $2.50.

Index to A.S.T.M. Standards and Tentative Standards

This Index is an adjunct to the "Book of A.S.T.M. Standards" and comprises a ready reference for locating any A.S.T.M. standard in the bound publication of the Society in which it appears. It should also be of service in ascertaining whether the Society has issued a standard on a specific subject. The subject index, listing 738 A.S.T.M. Standards and 431 Tentative Standards in effect as of December 1943, occupies 152 pages of the book; the numeric index, listing standards in continuous numeric sequence of A.S.T.M. Serial Designations, takes up 43 pages.

The Index is furnished as a service to each purchaser of any or all Parts of the 1942 Book of A.S.T.M. Standards, or any or all Parts of the 1943 Supplement to the Book of Standards.

The Practical Design of Welded Steel Structures

By H. Malcolm Priest

In this volume the author brings to the reader the results of his own study and experience in the field of welded construction. It provides in a compact form a practical working manual that will furnish the engineer and fabricator with the answers to many questions concerning the preparation and execution of welded designs. Brief discussions are given concerning the various welding processes, specifications for electrodes, types of welds, welding positions, qualification tests and inspection. The subject of weld geometry and stress concentration is treated at some length. Temperature effects, both physical and metallurgical have also received extended attention. One section deals with the codes of the American Welded Society, and unit stresses from these codes form the basis for numerous charts and tables throughout the book. Beam connections are fully treated and considered in the light of continuous structures. A brief section deals with rigid frames.

The book contains many clear and compact illustrations and a short bibliography of literature related to welded construction. It comprises 153 pages, size $5 \times 7^3/_4$ in., bound in cloth covers. Price $1.00.

Proceedings of the 4th Annual Water Conference of the Engineers Society of Western Pennsylvania

We have received an announcement from the Engineers Society of Western Pennsylvania that the Proceedings of its 4th Annual Water Conference are now available at $3.15 per copy, and can be secured by writing to the Society at the William Penn Hotel, Pittsburgh, Penna.

The date of the 5th Annual Water Conference is scheduled for October 30–31 at the same address.

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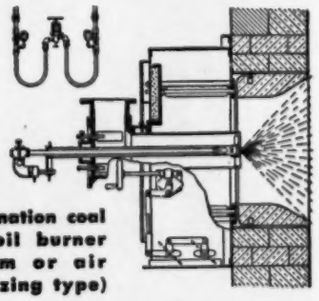
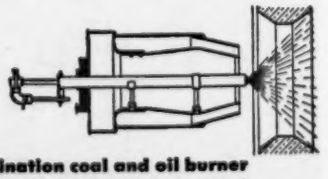


Combination coal and oil burner (Steam or air atomizing type)



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